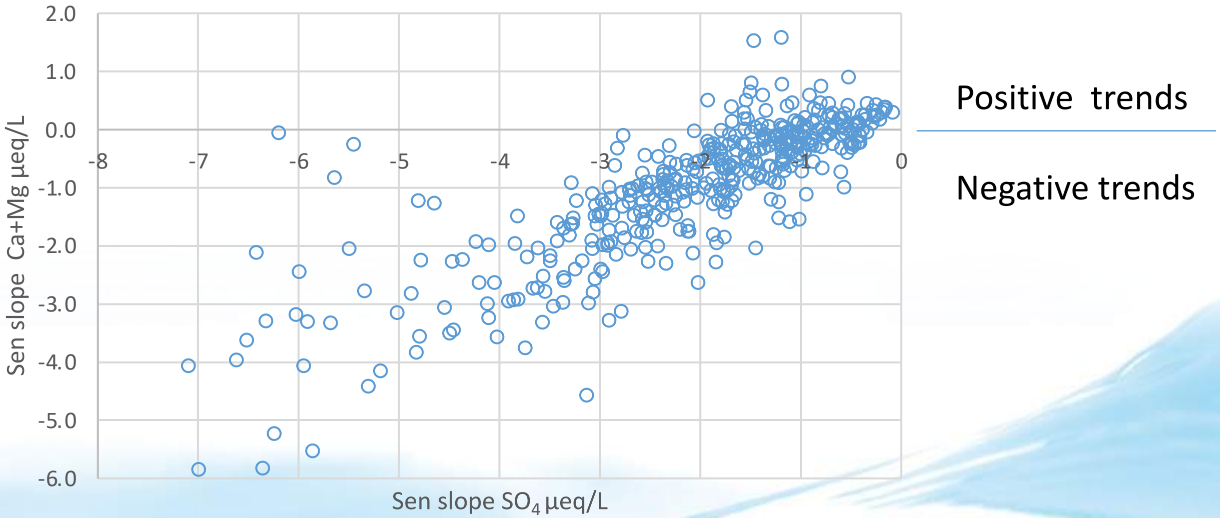
Diverging trends in Ca and Mg under chemical recovery

- Assessing relationships between trends in base cations relative to trends in sulphate, organic anions and bicarbonate



Rolf David Vogt, Kari Austnes, Heleen de Wit, Cathrine Brecke Gundersen

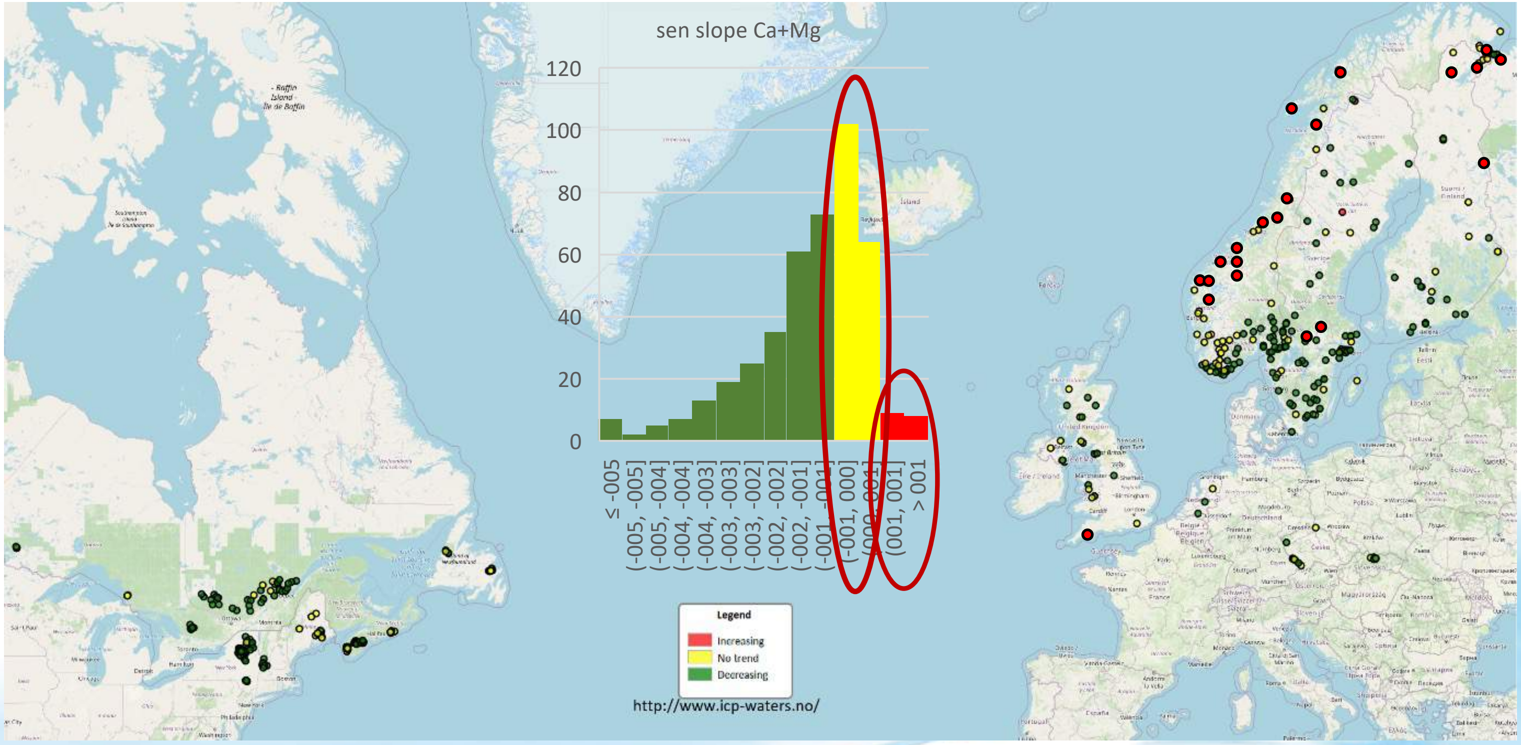
Background – Norwegian 1000 lake study

- Calcium concentrations had increased from 1995 to 2019 in all regions except in the strongest acid rain impacted south
  - Despite a significant decline in sulphate in all regions!

Region	SO_4 mg/L 1995/2019/%Δ	Ca mg/L 1995/2019/%Δ	Mg mg/L 1995/2019/%Δ	ANC μeq/L 1995/2019/Δ
South	2.4/0.8/−65****	0.8/0.7/−12**	0.32/0.25/−20****	2/41/39****
East	3.6/1.9/−47****	3.4/3.5/1n.s.	0.60/0.52/−12****	159/196/37****
Inland	1.5/1.0/−33****	1.3/1.8/36****	0.22/0.25/13**	59/105/46****
West	1.9/1.2/−38****	1.0/1.3/35****	0.36/0.35/-2n.s.	27/70/42****
Central	1.5/1.1/−26****	1.9/2.4/26****	0.40/0.47/16****	100/141/41****
North	2.5/2.1/−17****	3.6/4.2/15****	0.86/0.91/6*	217/265/48****
Norway	2.3/1.4/−39****	2.0/2.3/14****	0.48/0.48/0n.s.	97/139/42****

Extract of Table 2 in de Wit et al. (2023)

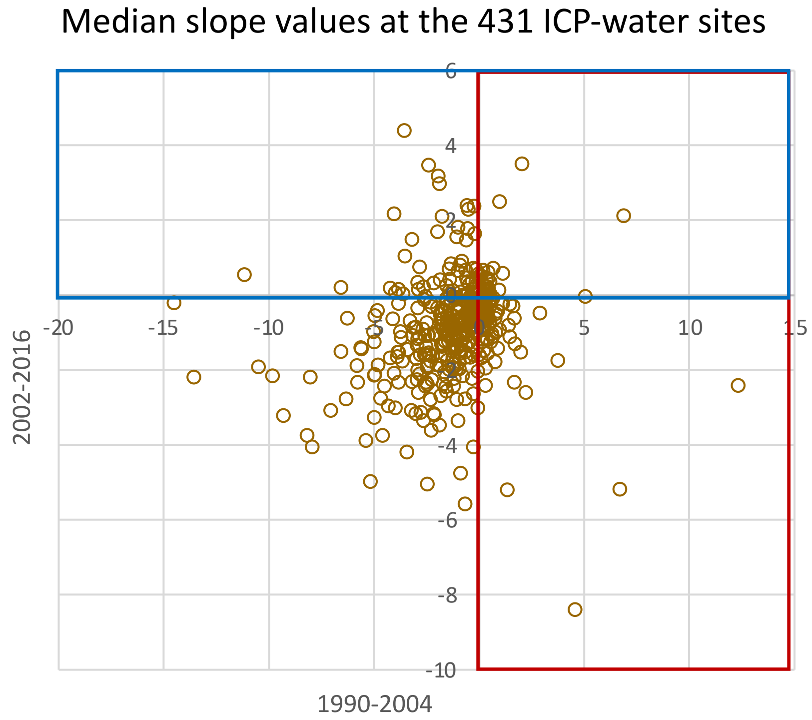
This is also observed in several ICP-water sites



Number of sites with positive $Ca^{2+} + Mg^{2+}$ slopes are increasing

- Number of site with positive slopes increased from the first period

  to the last period



Conflicting rationale

- Adhering to the principle of charge balance, the decline in SO_4^{2-} anion concentrations is expected to be accompanied by a decline in Ca^{2+} and Mg^{2+} concentrations in acid sensitive regions (Reuss & Johnson, 1985)

$$Ca^{2+}+Mg^{2+}+Na^{+}+K^{+}+H^{+}+NH_4^{+} = SO_4^{2-}+NO_3^{-}+Cl^{-}+OA^{-}+HCO_3^{-}$$

- But we are now in an era of low S deposition, so changes in other anions than SO_4^{2-} are apparently more important

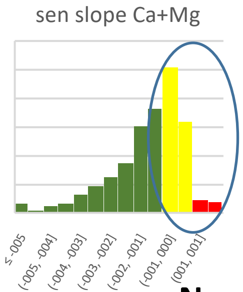
Which other ions are these?

Justification

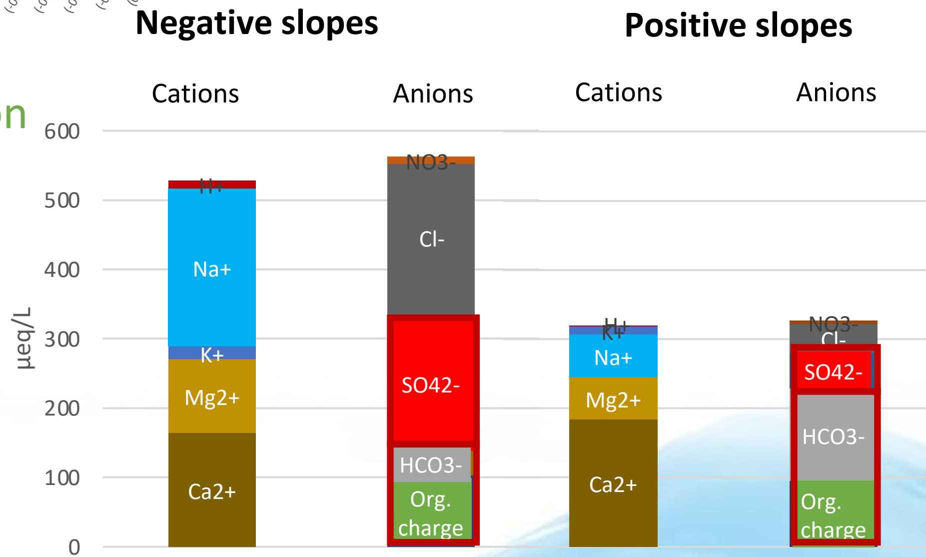
- To predict chemical recovery, we need to understand the governing mechanisms
- We are surprised by upward trends in Ca^{2+} and Mg^{2+}
  - What are the important processes?
  - Do we need to change the models that predict chemical recovery?

What do the data tell us?

Sites with increasing $Ca^{2+} + Mg^{2+}$ have:



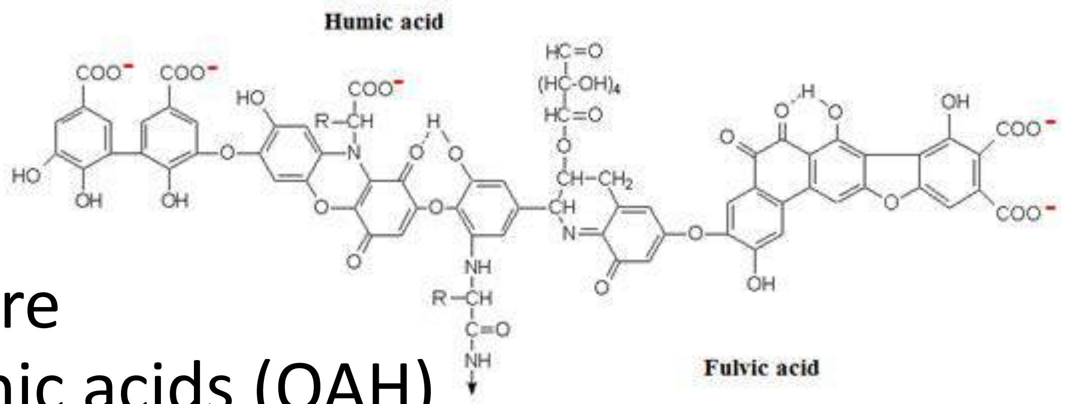
- Minor acid rain loading
  - Lower median SO_4^{2-}
  - More Bicarbonate and less Organic anion concentrations
    - Less decreasing slopes in SO_4^{2-}, as well as less increase in Organic anions

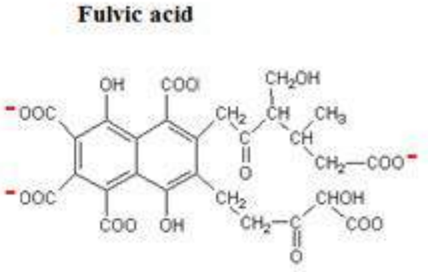


I.e., this is less acidified acid sensitive sites

How to estimate levels of Bicarbonate and Organic acid anions ?

Organic acid anions (OA^-)

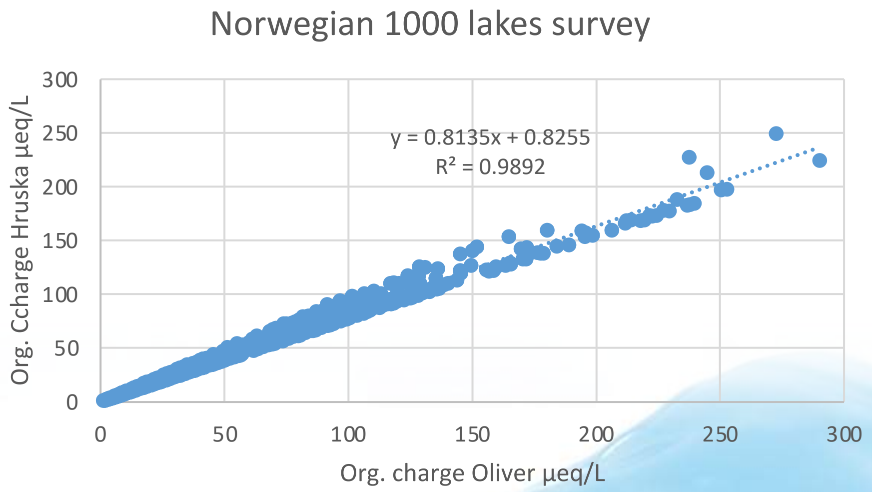




- Organic anions (OA^-) are protolyzed weak organic acids (OAH)
  - Dependent on the pH and site density
  - Different models available
    - pH adjusted site density (Oliver et al., 1983)
    - Triprotic analogue (Cosby et al., 2001), pKa values (3.04; 4.51; 6.46) from Hruska et al. (2003)
    - 1/3 of site density (Lydersen et al., 2004)

Approach – Organic anions

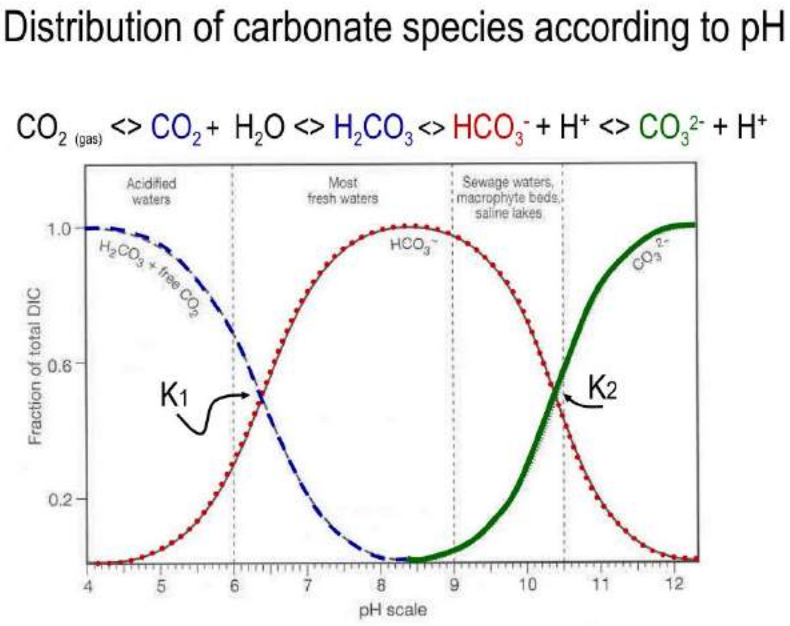
- Oliver and the Hruska models are correlated in the 1000 lakes data
    - STD in %IB slightly lower with Hruska (6) than with Oliver (8)



Bicarbonate (HCO_3^-)

- Equilibrium between species is pH dependent

- Commonly derived from Alkalinity measures
  - Inconsistent alkalinity data as it is measured using different methods (e.g., Gran plot titration, One and two End point titration to different end points, Colorimetry and unspecified)



Approach – HCO_3^- based on ANC

- HCO_3^- in the ICP-Water data are calculated based on ion balance:

$$ANC = Ca^{2+} + Mg^{2+} + Na^{+} + K^{+} + NH_4^{+} - SO_4^{2-} - NO_3^{-} - Cl^{-}$$

$$= H^{+} - (OA^{-} + HCO_3^{-})$$

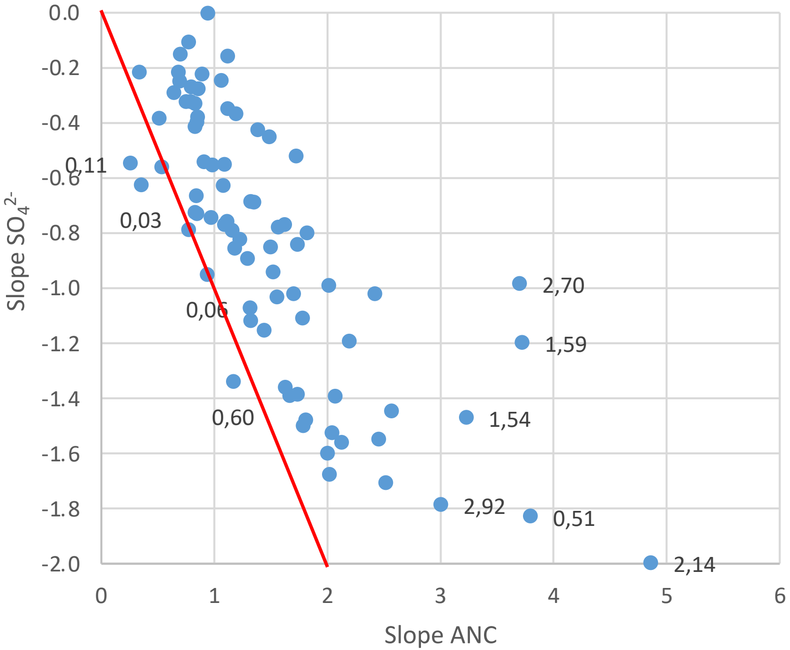
$$HCO_3^{-} = ANC + H^{+} - OA^{-}$$

  - This is assuming that $Al(OH)_n^{3-n}$ and $Fe(OH)_n^{3-n}$ are insignificant

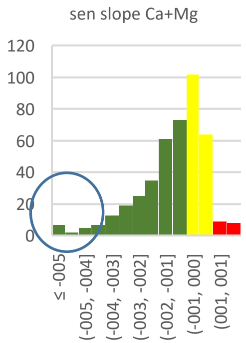
At sites with positive Ca^{2+}+Mg^{2+} slopes the increase in ANC > decline in SO_4^{2-}

- Sites where the negative slope of SO_4^{2-} is similar to the positive slope of ANC (red line) generally have Ca^{2+}+Mg^{2+} slopes close to zero
- Where increase in ANC >> decrease in SO_4^{2-} there are high slopes of Ca^{2+}+Mg^{2+}
- The increase in ANC is due to a **larger** increase in Ca^{2+}+Mg^{2+} than the decrease in SO_4^{2-}
- As the increase in Organic anions is **limited** the increased ANC must be mainly governed by increased HCO_3^-.

Relationship between slope in sulphate and slope in ANC at the sites (80) with positive slopes of Ca^{2+}+Mg^{2+} (data labels)



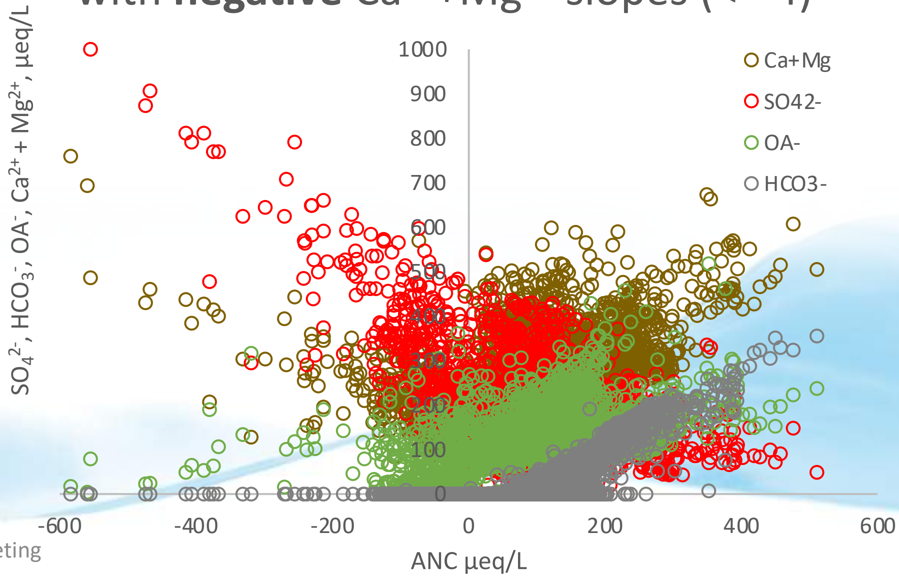
Cause for the increase in ANC differ



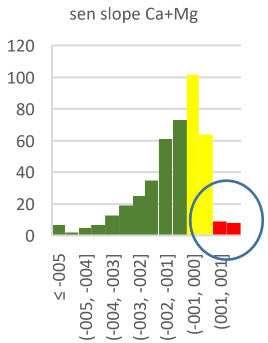
- At sites with **negative** Ca^{2+}+Mg^{2+} slopes the ANC has increased (0.02) due to **larger** decline in the strong acid anion SO_4^{2-} (-0.04) than in Ca^{2+}+Mg^{2+} (-0.01), mainly compensated by an increase in OA^-, and by HCO_3^- at high ANC

- This is partly observed as co-variation between SO_4^{2-}, OA^-, HCO_3^- & Ca^{2+} + Mg^{2+} vs. ANC at sites with large negative Ca^{2+} + Mg^{2+} slopes (i.e., < -4)

Data from 21 ICP-Water sites with **negative** Ca^{2+}+Mg^{2+} slopes (< - 4)

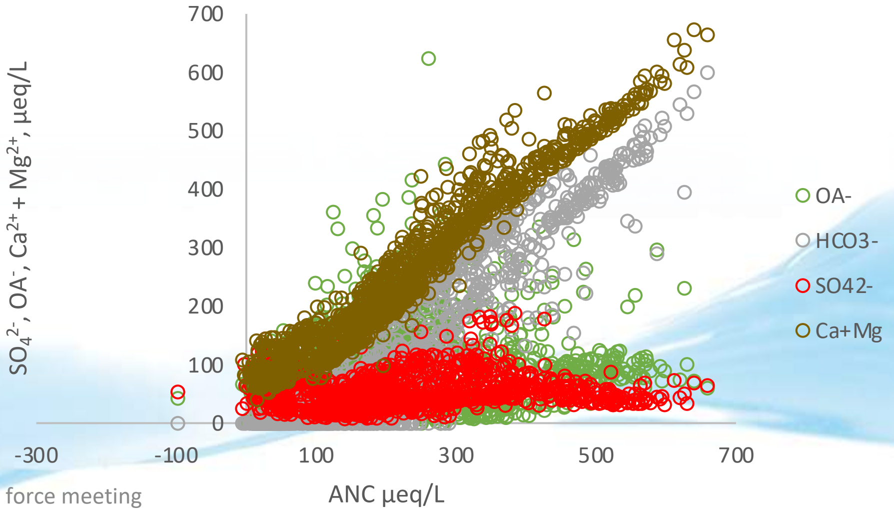


Cause for the increase in ANC differ



- At the sites with **positive** Ca^{2+}+Mg^{2+} slopes the ANC has increased due to increased HCO_3^-, balancing the increase in Ca^{2+}+Mg^{2+}
  - OA^- and SO_4^{2-} has low explanatory value

Data from 19 ICP-water sites with **positive** Ca^{2+}+Mg^{2+} slopes (> 0.5)



Summing up

At most sites the Ca^{2+} + Mg^{2+} decline alongside SO_4^{2-}, though Ca^{2+} + Mg^{2+} show small (unexpected) upward trends in less acid-sensitive sites with little acid deposition

- The increase in ANC where the decline in acid rain has been **large** is mainly comprised by an increase in **organic acids**
    - Browning impacts Ca^{2+} + Mg^{2+} declines
- The increase in ANC where the acid rain deposition has been **small** is mainly comprised by an increase in **HCO_3^-**
    - Bicarbonate buffers more than we expected

We hypothesise that this increase in bicarbonate is driven by increased greenhouse gas CO_2 and biomass

- What do you think?

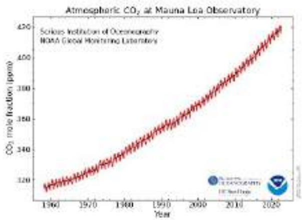
Hypothesis (de Wit et al., 2023)

Increase in Ca^{2+} is due to the overall increase in CO_2 in the atmosphere and biomass

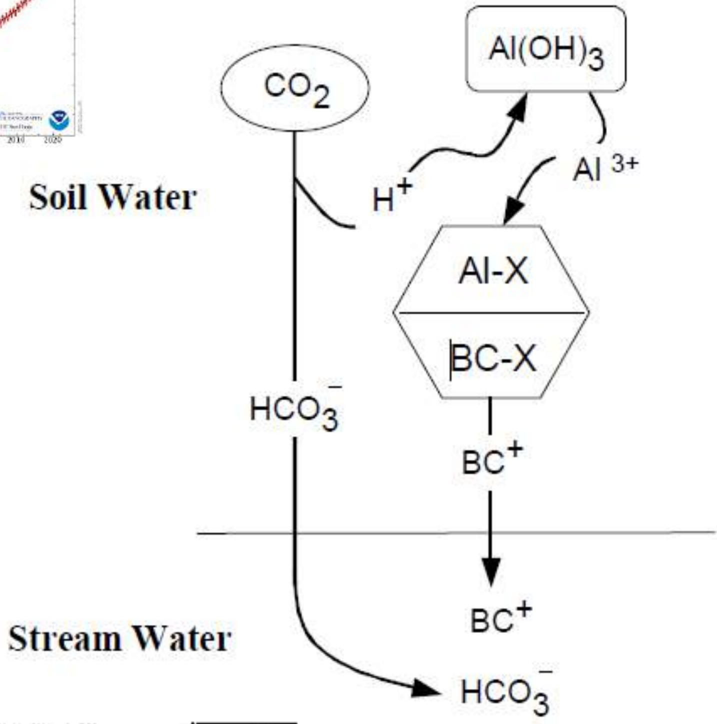
Leading to increased soil respiration and thereby carbonic acid

Carbonic acid increases weathering, releasing Ca^{2+} and bicarbonate	**Thus, positive Ca^{2+} slopes are due to increased bicarbonate, driven by increased greenhouse gas CO_2**	This is happening "at all ICP-water sites", but is neutralized by low pH and overwhelmed by the decline in acid rain

Increased CO_2



- Increased soil respiration due to increased biomass and atmospheric CO_2 (CO_2 pump) leading to increased carbonate alkalinity
  (Comstedt et al., 2006)



Ecosystems (2006) 9: 1266–1277
DOI: 10.1007/s10021-006-0110-5
ECOSYSTEMS

Effects of Elevated Atmospheric Carbon Dioxide and Temperature on Soil Respiration in a Boreal Forest Using $\delta^{13}C$ as a Labeling Tool

Daniel Comstedt,[1*] Björn Boström,[1] John D. Marshall,[2] Anders Holm,[1] Michelle Slaney,[3] Sune Linder,[3] and Alf Ekblad[1]

Hydrology and Earth System Sciences, 5(1), *83–91* (2001) © EGS
Hydrology & Earth System Sciences

Long-term and seasonal variations in CO_2: linkages to catchment alkalinity generation

Stephen A. Norton[1], Bernard J. Cosby[2], Ivan J. Fernandez[3], Jeffrey S. Kahl[4] and M. Robbins Church[5]

[1]Dept. of Geological Sciences, University of Maine, Orono, ME, USA
[2]Dept. of Environmental Sciences, University of Virginia, Charlottesville, VA, USA
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[4]George J. Mitchell Center, University of Maine, Orono, ME, USA
[5]US Environmental Protection Agency, Corvallis, Oregon, USA

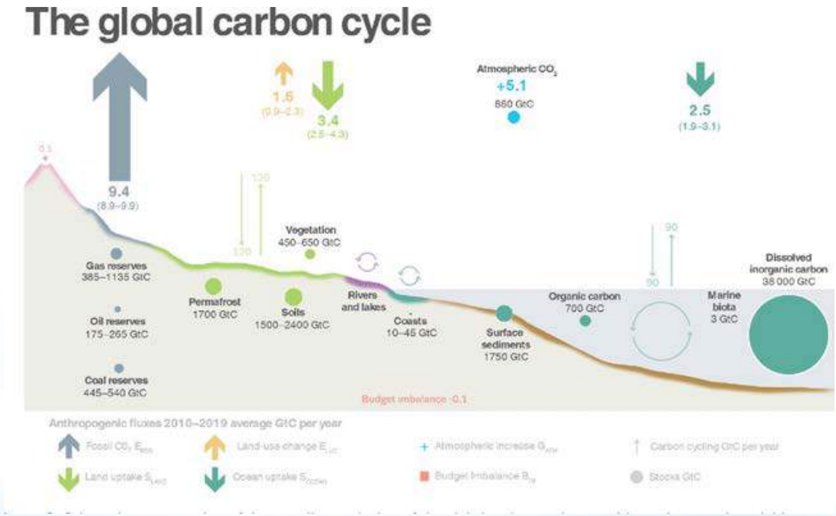
e-mail for corresponding author: Norton@Maine.Edu

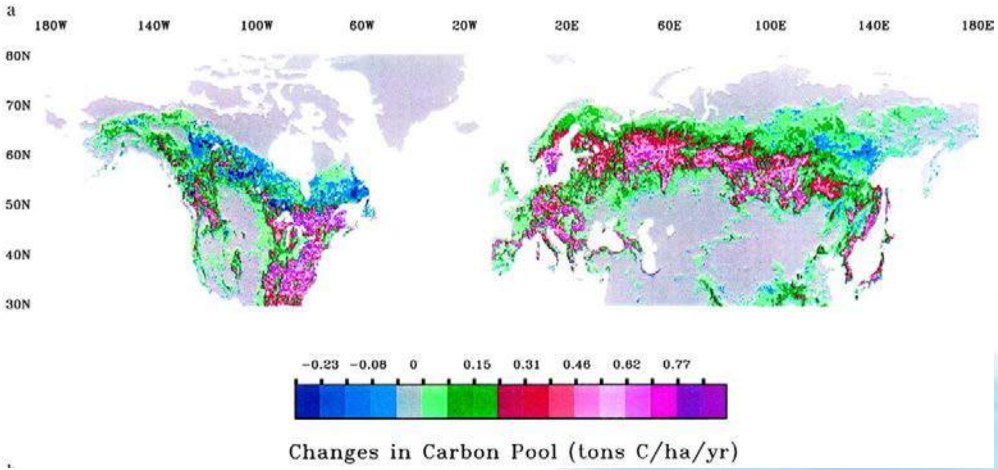
Norton et al., 2001

NIVA

Increased biomass

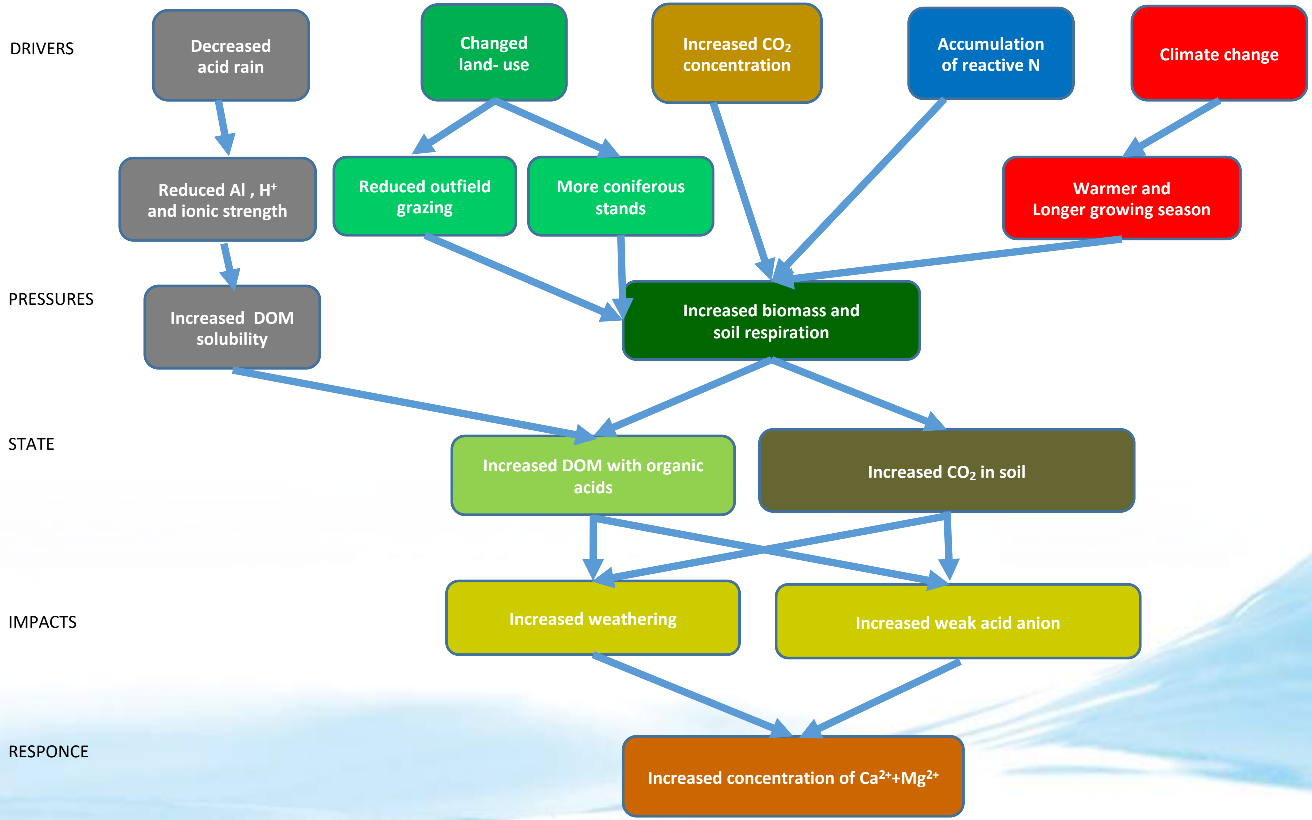
- Approx. 20 % of the global CO_2 emitted has been sequestrated by increased biomass





Friedlingstein et al., 2020. Global Carbon Budget, Earth System Science Data

Conceptual cause response relationship between drivers, pressures, state, impacts and responses regarding counteracting the effect of decreased SO_4^{2-} concentration on temporal trends in Ca^{2+}+ Mg^{2+}



Timeline for Ca report

- August 2023: Draft report available for review by co-authors
  - All contributors will be co-authors of the report
- September 2023: Deadline for review
- October 2023: Revised report
- November 2023: Report submitted

Thanks for contribution of data:
Jens Arle (UBA), Jens Fölster (SLU), Daniel Houle (EC), Jakub Hruška (CGS), Iveta Indriksone (LEGMA), Don Monteith (UKCEH), Michela Rogora (CNR ISE), James E. Sample (NIVA), Sandra Steingruber (TI), John L. Stoddard (US EPA), Reet Talkop (APD), Wayne Trodd (IEPA), Rafał Piotr Ulańczyk (IEP-NRI), Jussi Vuorenmaa (SYKE)

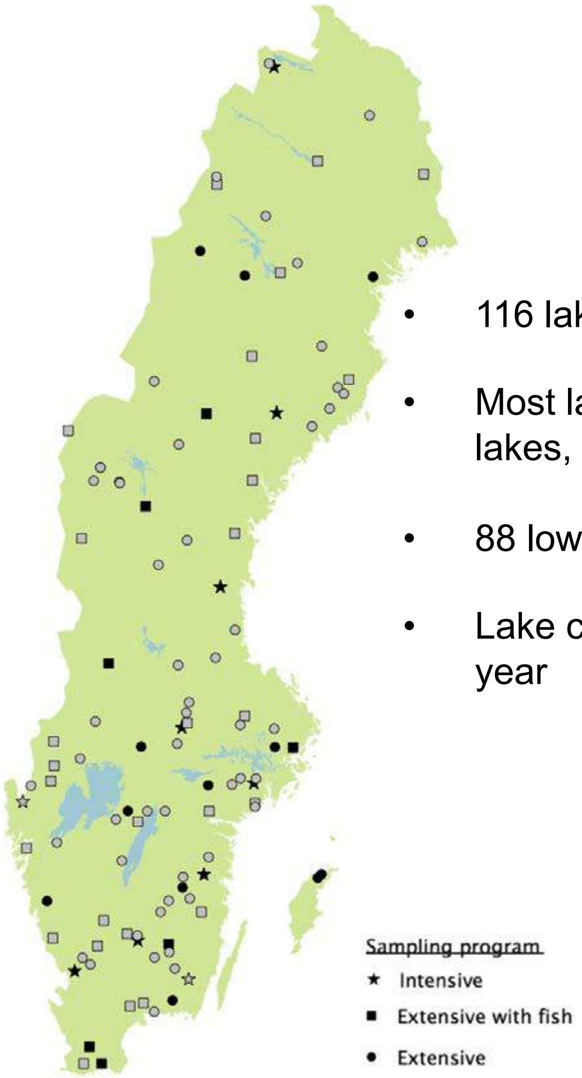
Trends in lake chemistry from Swedish national monitoring

Jens Fölster, Claudia von Brömssen, Karin Eklöf
Swedish University of Agricultural Sciences

Havs och Vatten myndigheten

National lake monitoring

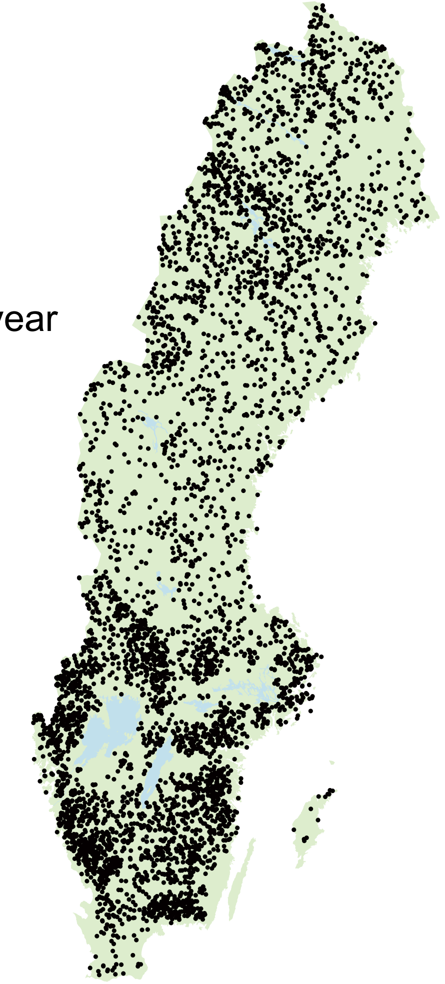
Trend lakes



- 116 lakes
- Most lakes are references to limed lakes, data since 1980ies
- 88 low alkalinity sites (< 0,2 mekv/l)
- Lake chem sampled 4-8 times a year

Lake survey

- 4 800 lakes
- Stratified random selection
- 65% low alkalinity
- Autumn sampling every 6th year in rotating panel

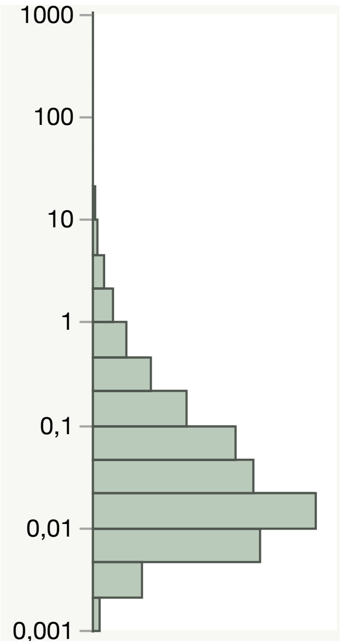


Representativeness of the trend lakes

Lake area km^2

All lakes in the national lake register

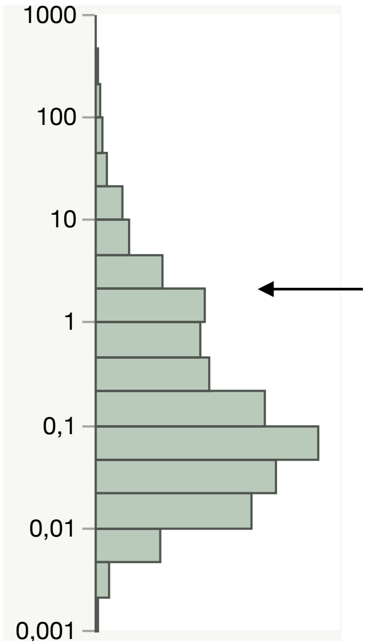
N= 95 000



Lake survey

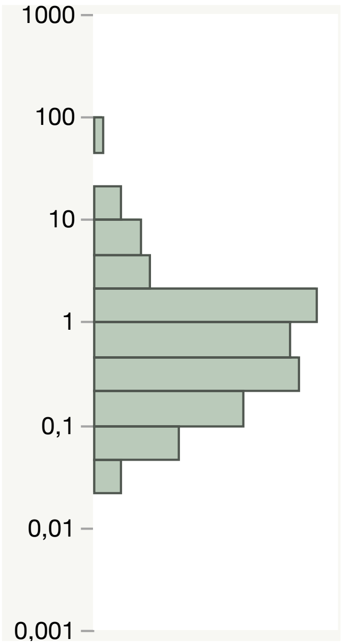
Stratified random selection

N= 4 800



National trend lakes

N= 110



Representativeness of the trend lakes

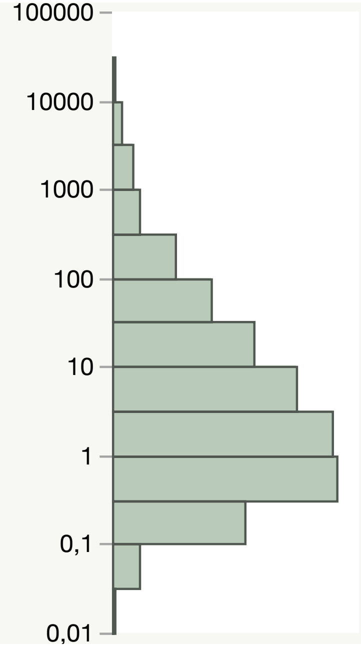
Catchment area km^2

All lakes in the national lake register

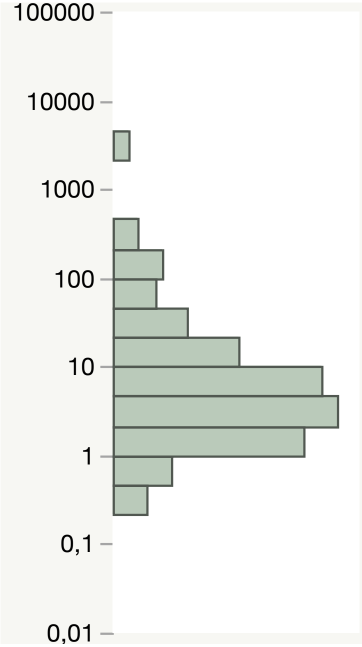
No data

Lake survey

Stratified random selection



National trend lakes

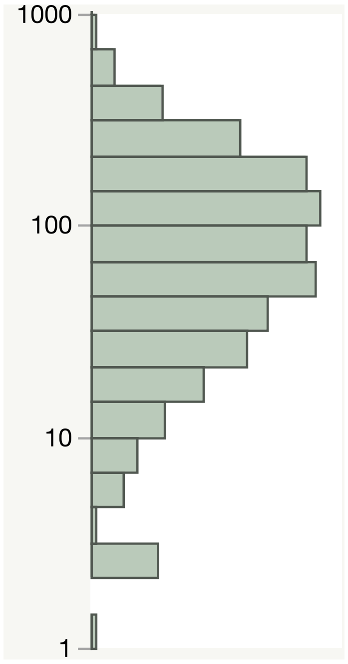


Representativeness of the trend lakes

Colour

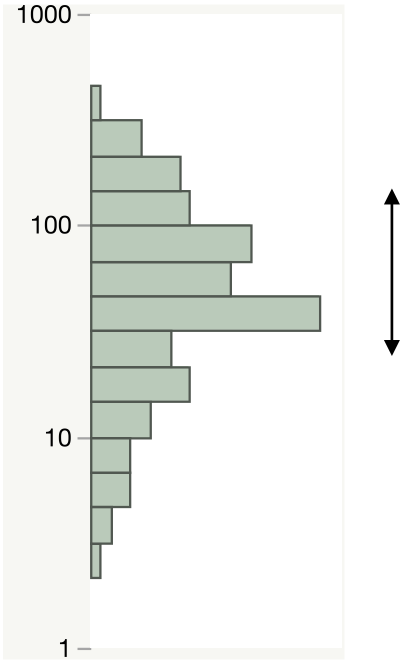
Lake survey

Median 69 mg Pt/l



National trend lakes

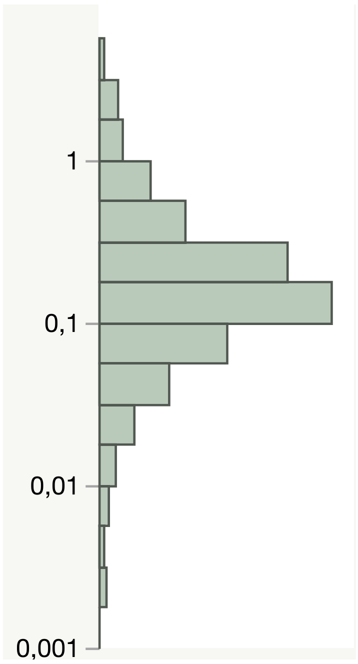
Median 45 mg Pt/l



Alkalinity mekv/l

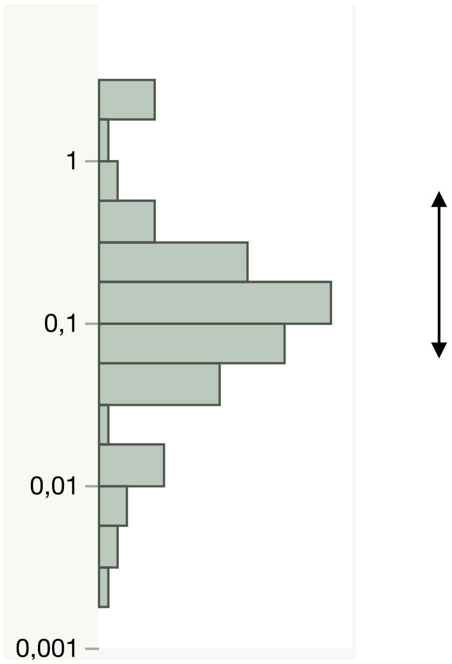
Lake survey

Median 0,137 mekv/l



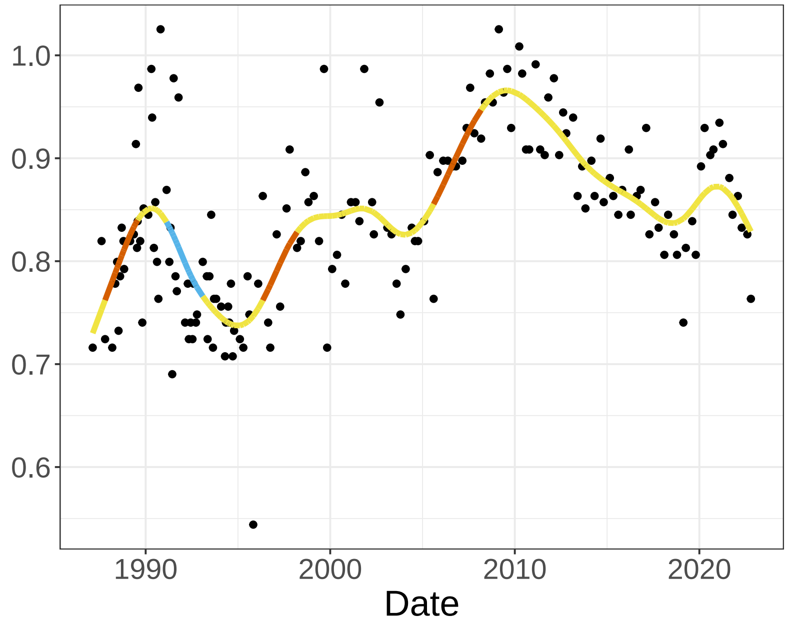
National trend lakes

Median 0,010 mekv/l



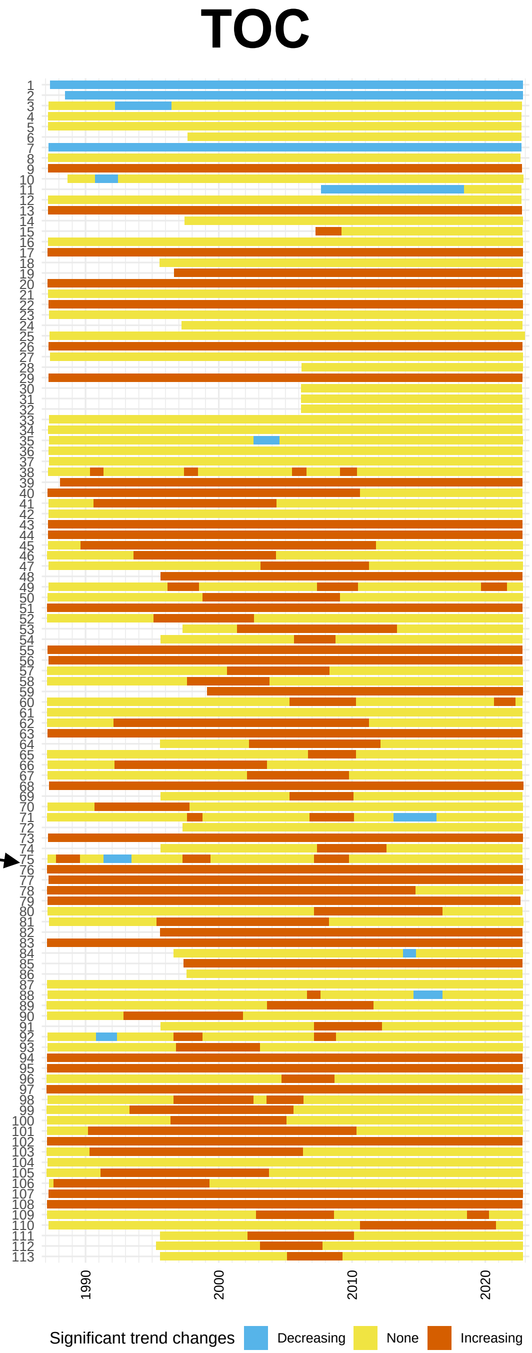
GAMM models

- Degree of smoothing selected by cross validation
- Significant trends defined by the confidence band of the derivative



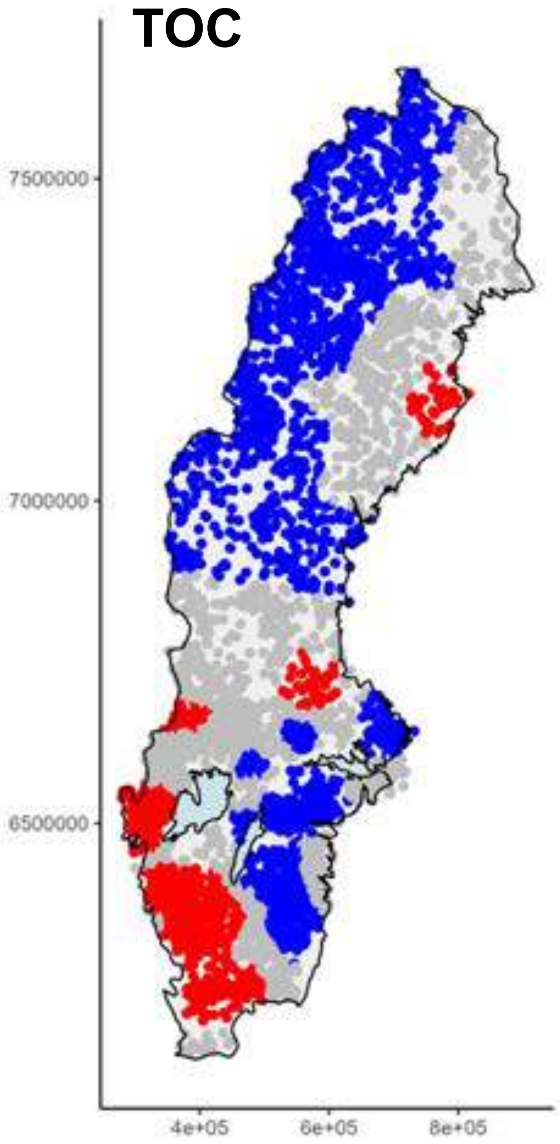
Simpson, G.L., 2018. Modelling Palaeoecological Time Series using Generalized Additive Models.

von Brömssen, C., S. Betnér, J. Fölster and K. Eklöf (2021). "A toolbox for visualizing trends in large-scale environmental data." Environmental Modelling & Software **136**: 104949.



Geographical regression

- 4 800 lakes
- 2008-2021
- 2-3 autumn samples per lake
- Station wise mean centering and log transformation
- Geographical weighted regression
  - Regression window selected by cross validation



von Brömssen, C., J. Fölster and K. Eklöf (2023). "Temporal trend evaluation in monitoring programs with high spatial resolution and low temporal resolution using geographically weighted regression models." Environmental Monitoring and Assessment **195**(5): 547.

SLU

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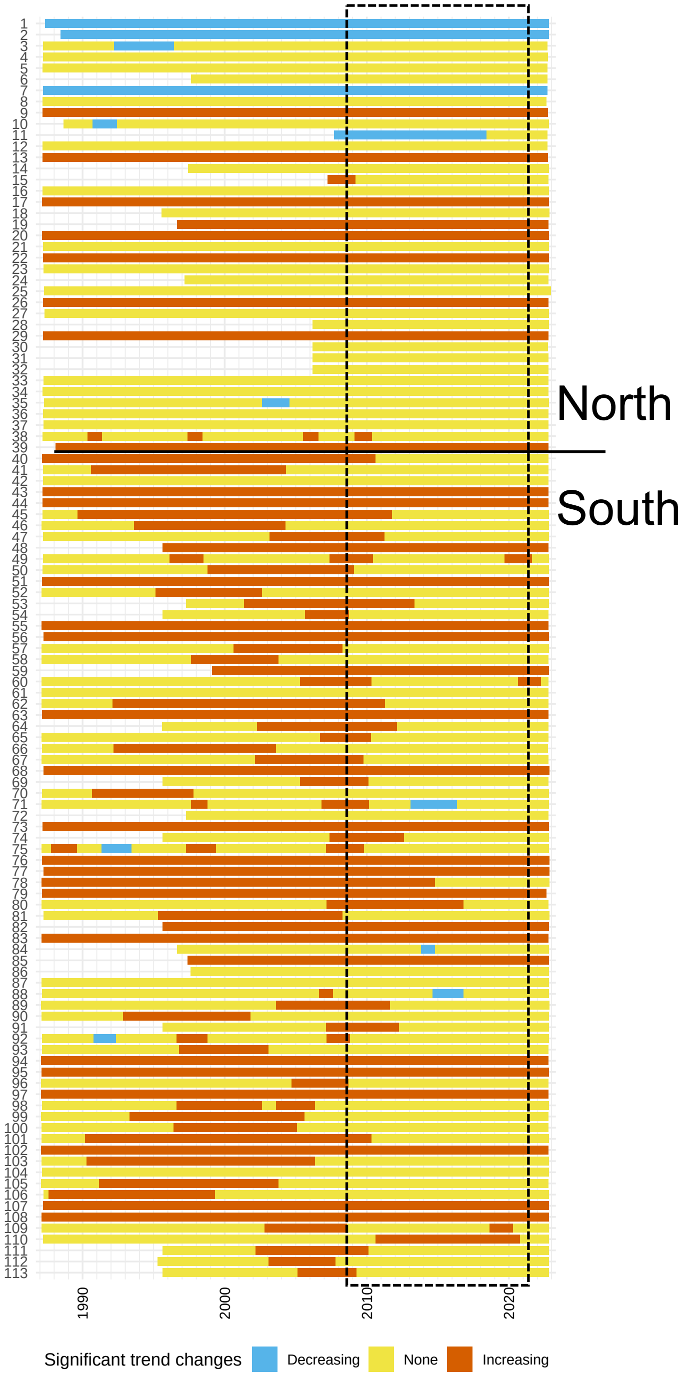
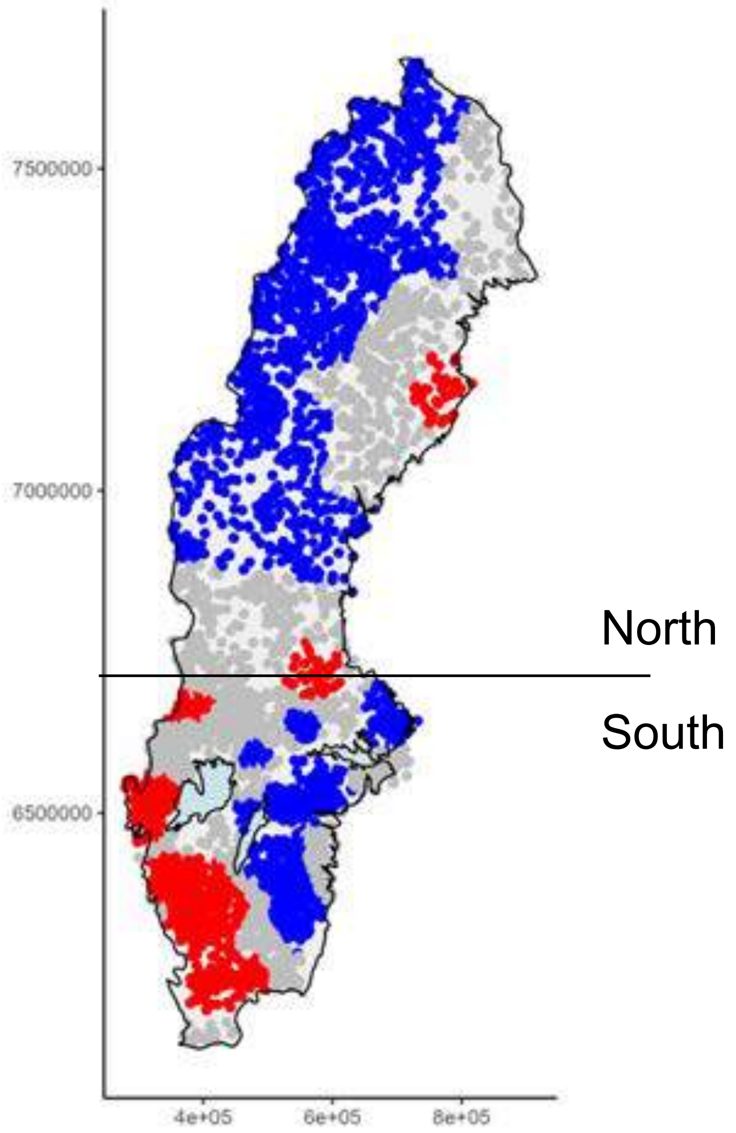
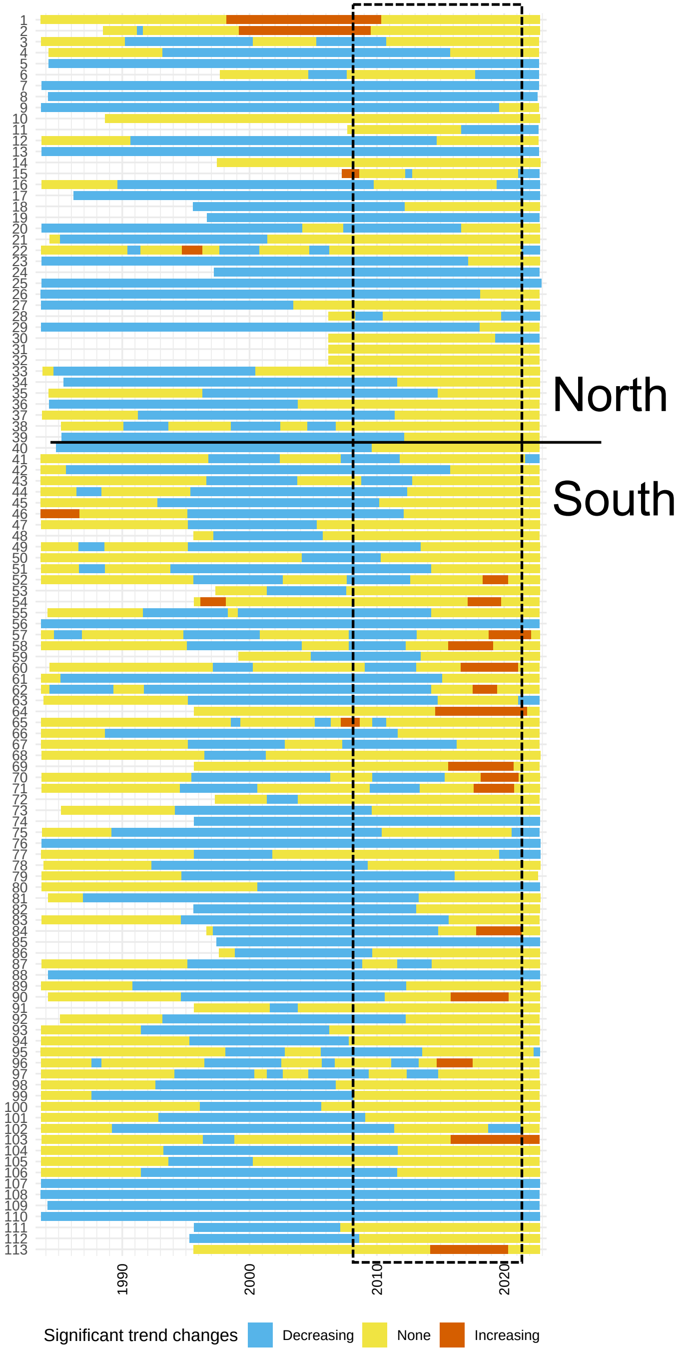


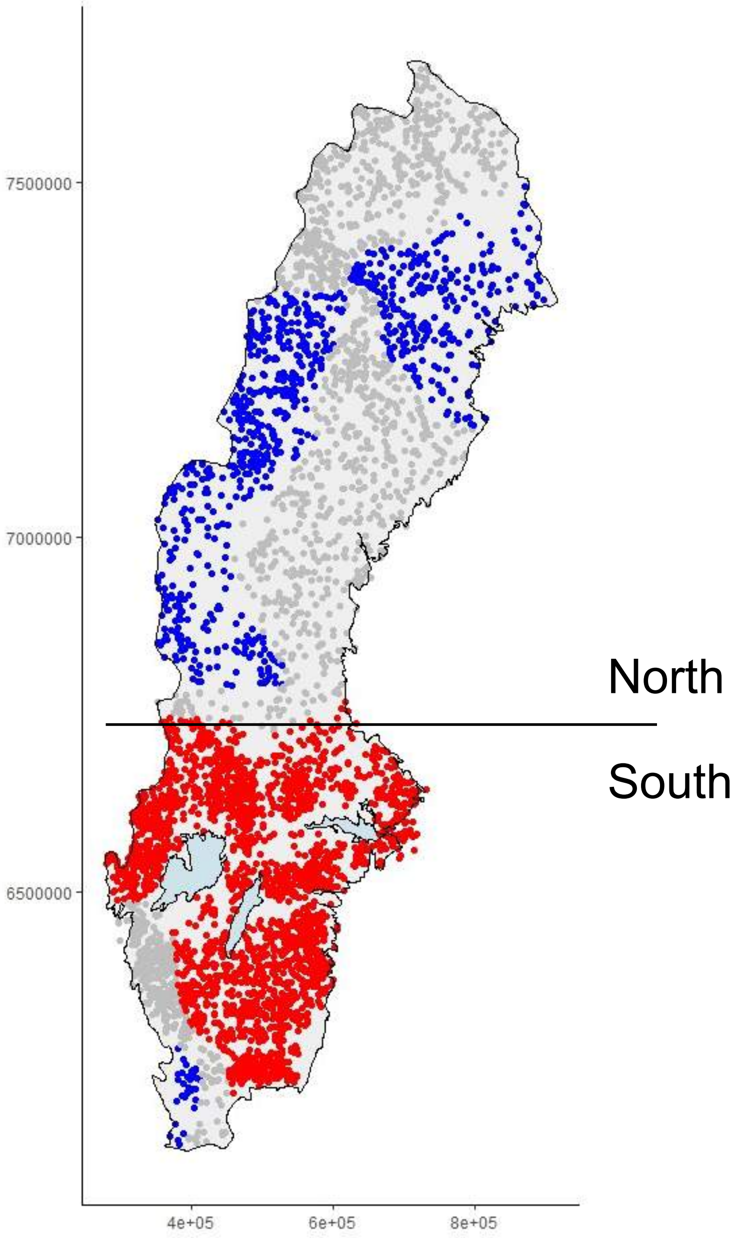
2008-2021



SO4



2008-2021



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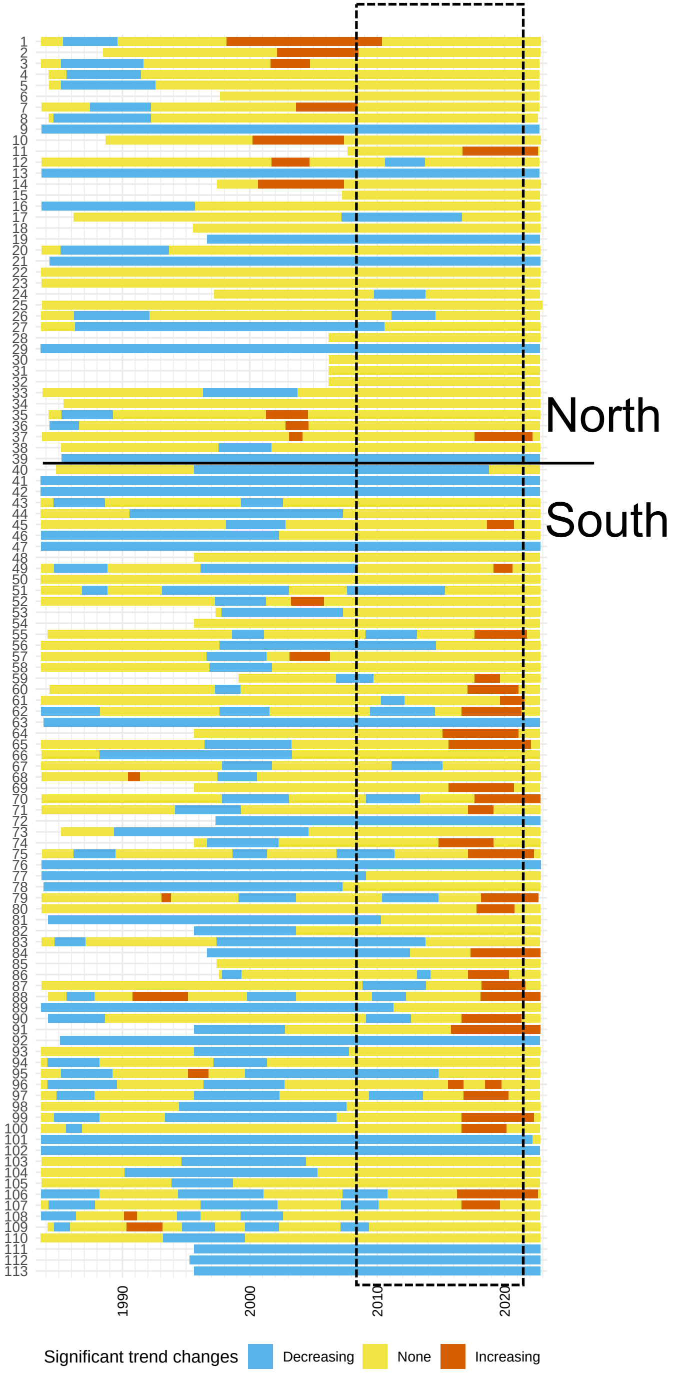
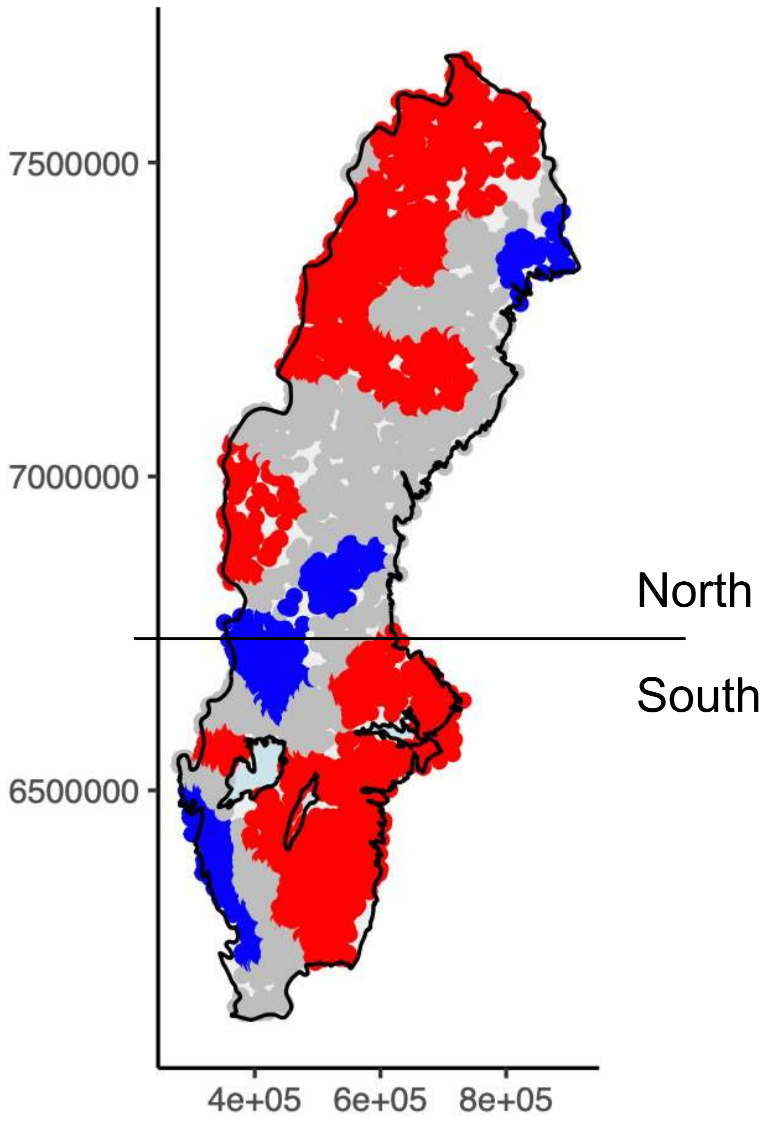
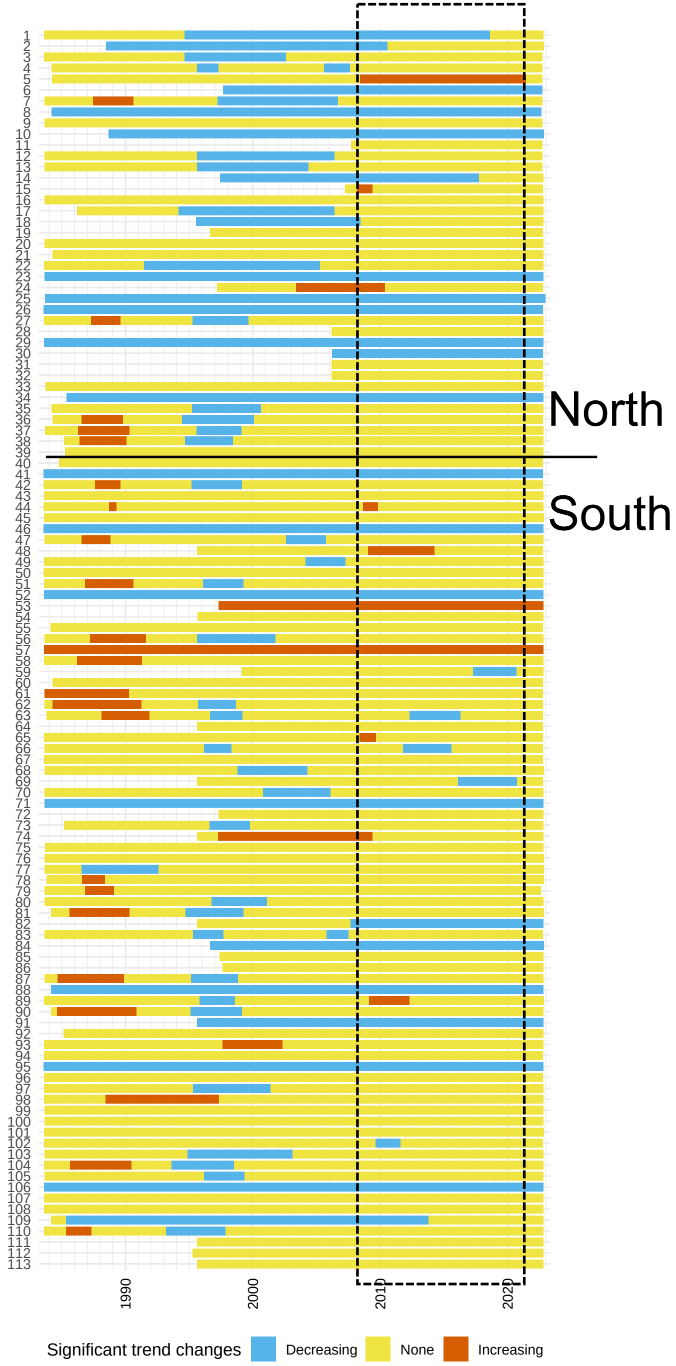
Ca



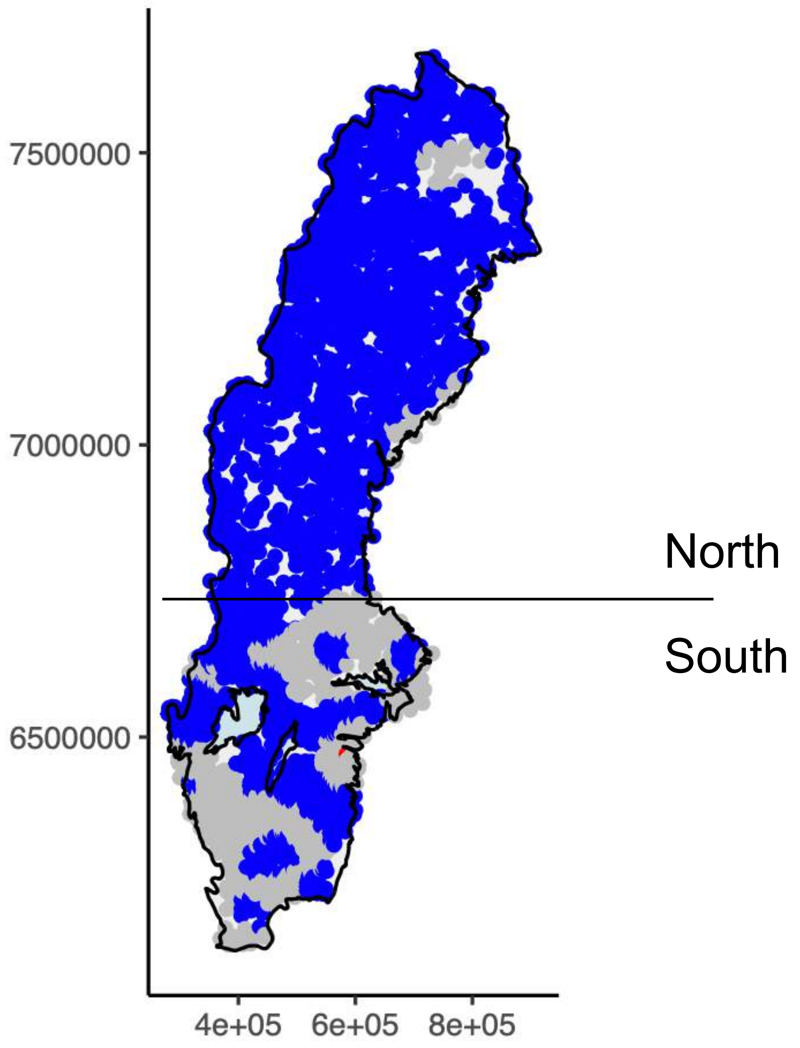
2008-2021



TotP

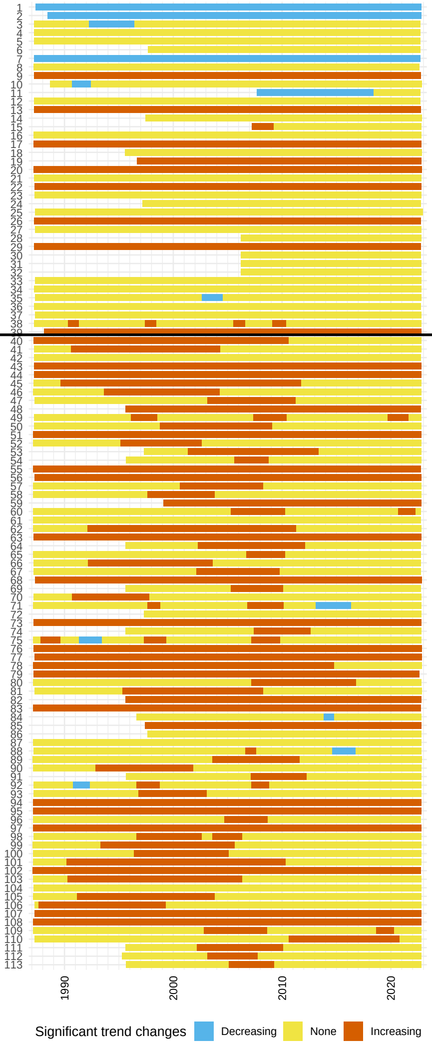


2008-2021



Reasons for differences?

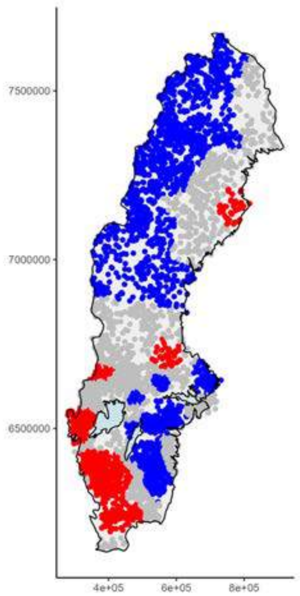
- Different populations
- Different sampling timing
  - Autumn samples every 6th year – lake survey
  - 4 samples per year seasonally – trend lakes
- Different statistical methods
  - Different powers?
  - Geographic regression - fixed time window



North

South

2008-2021



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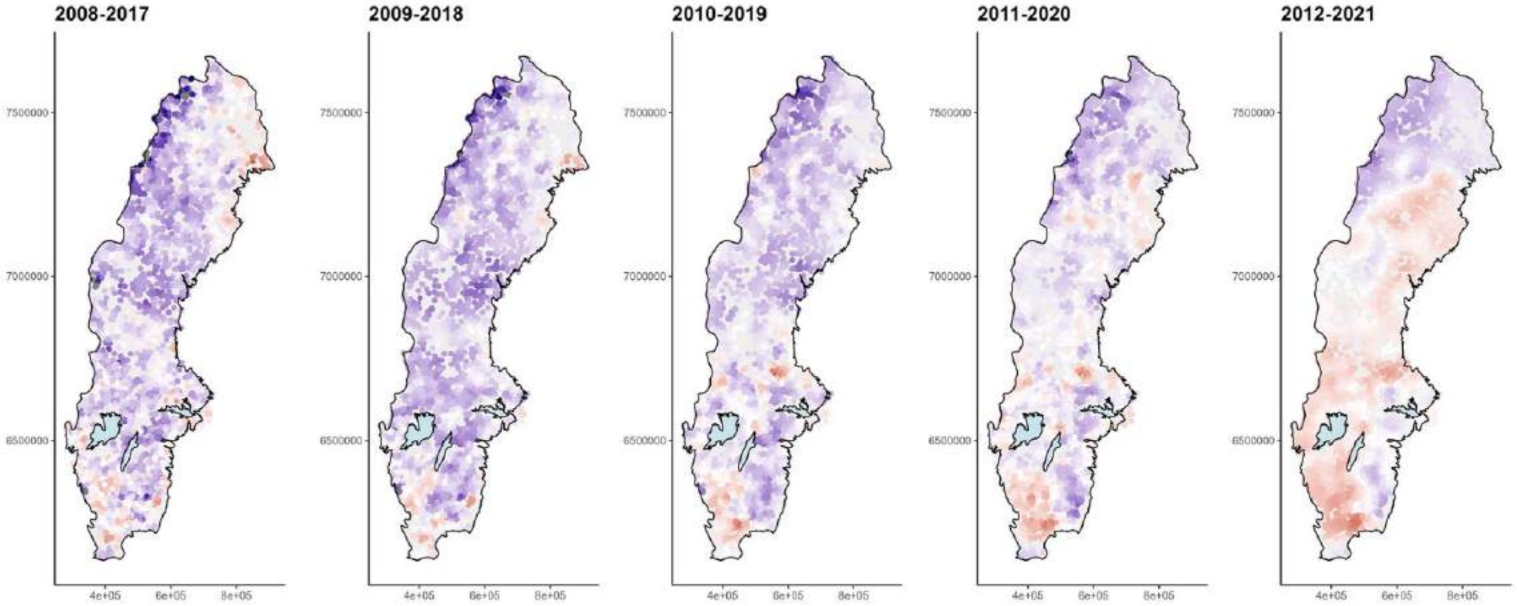
Moving 10-year windows



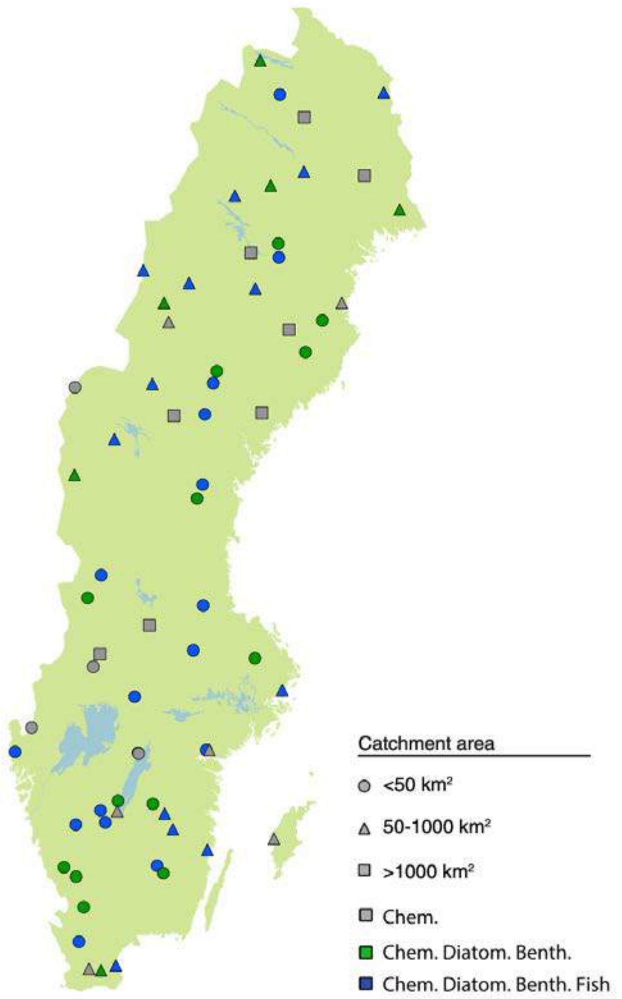
Conclusions

- The national programs of trend lakes and lakes surveys in rotating panel gives a unique (?) possibility to study the spatiotemporal variability in water chemistry
- State of the art statistical methods enhance the possibilities to do this
- Climate variation is now probably more important than decline in deposition
- More work is needed to explain the difference between the two datasets

Thank you!

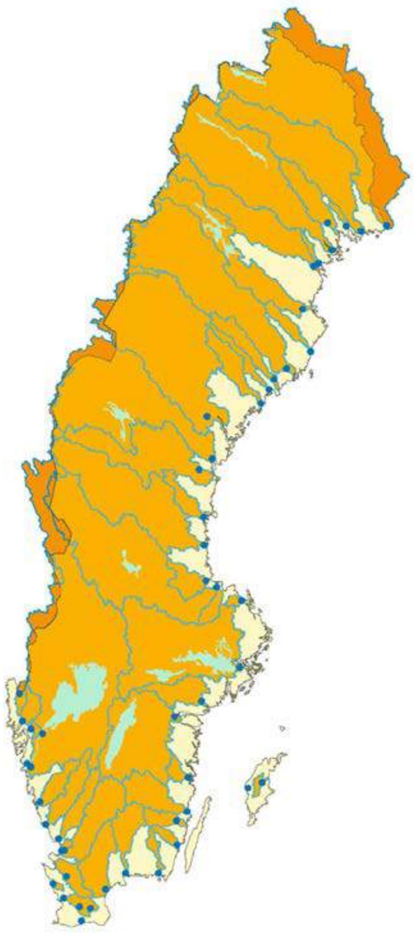
National river monitoring

67 Trend rivers

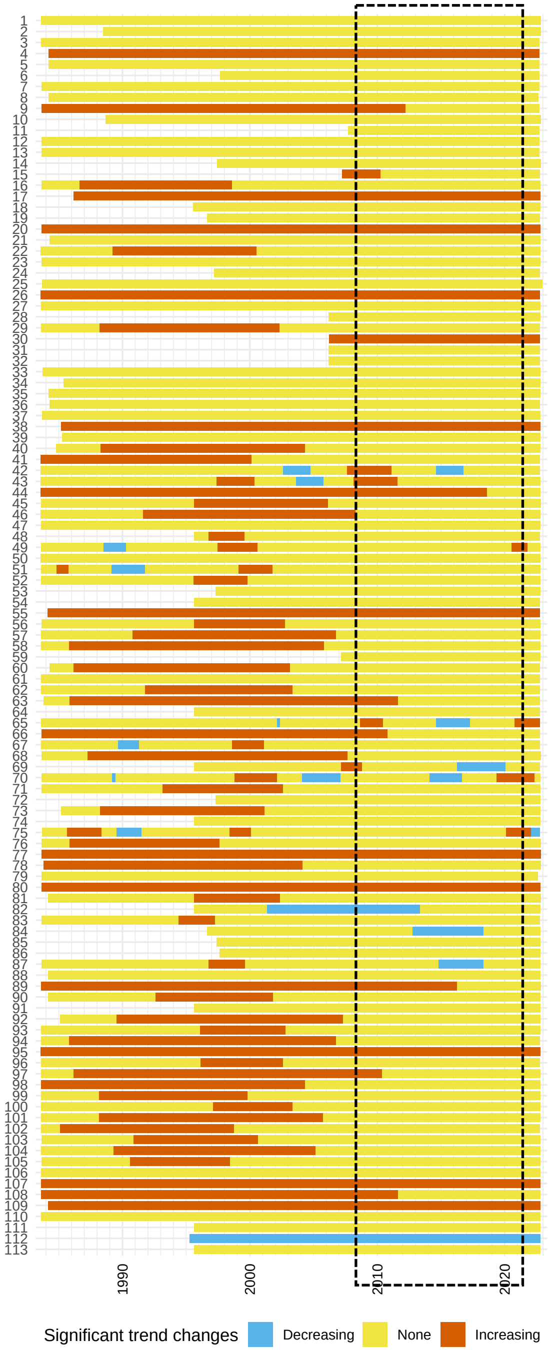


11 Lime effect references

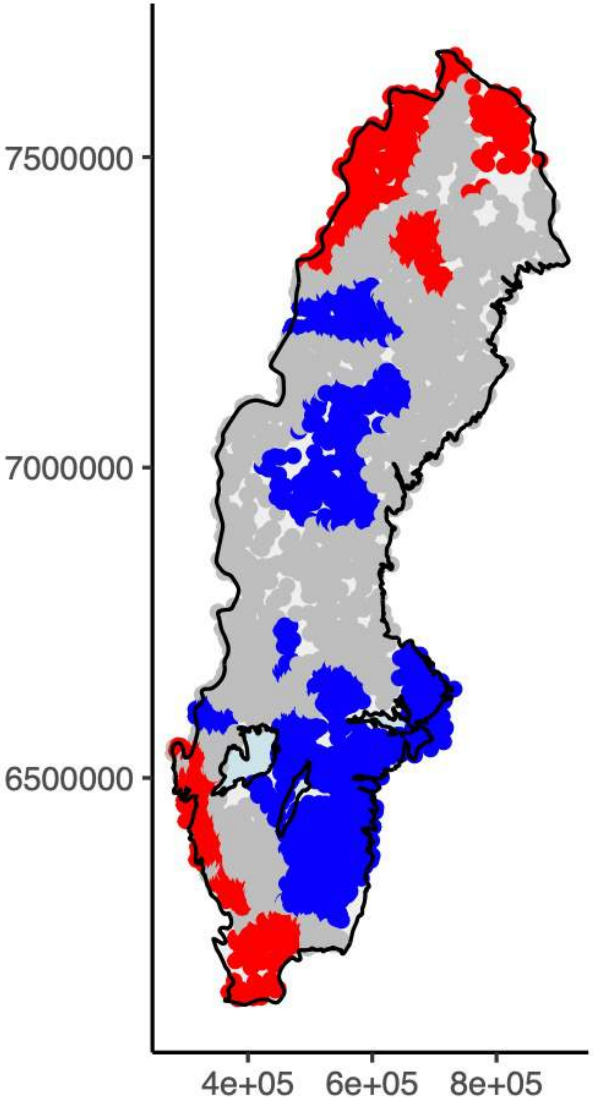
47 River mouths



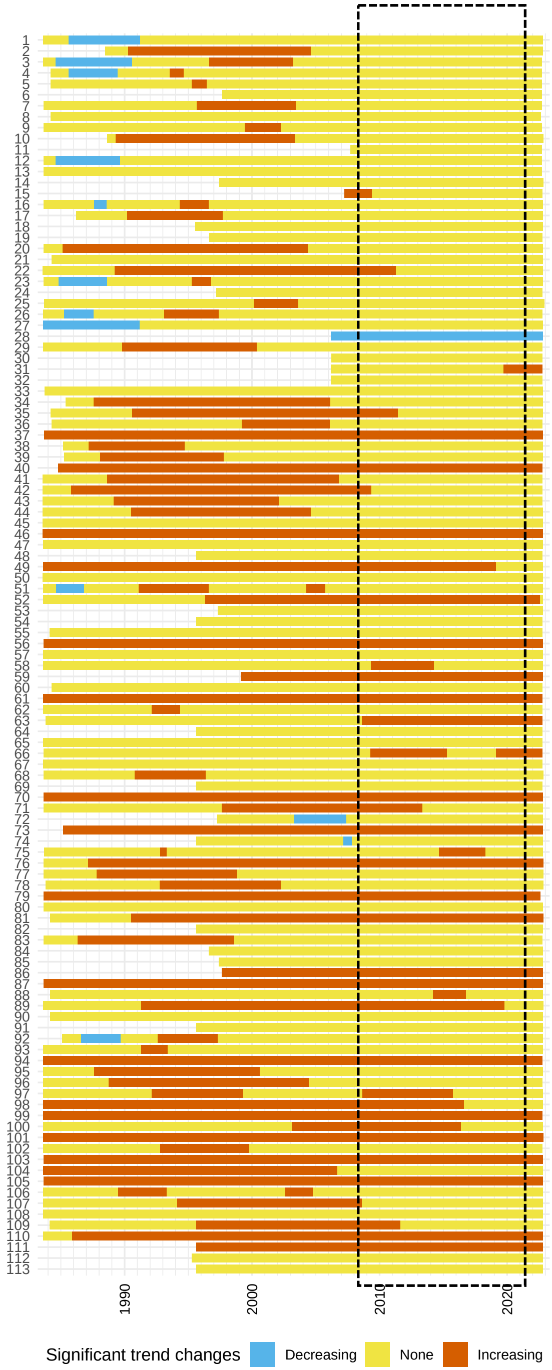
AbsF



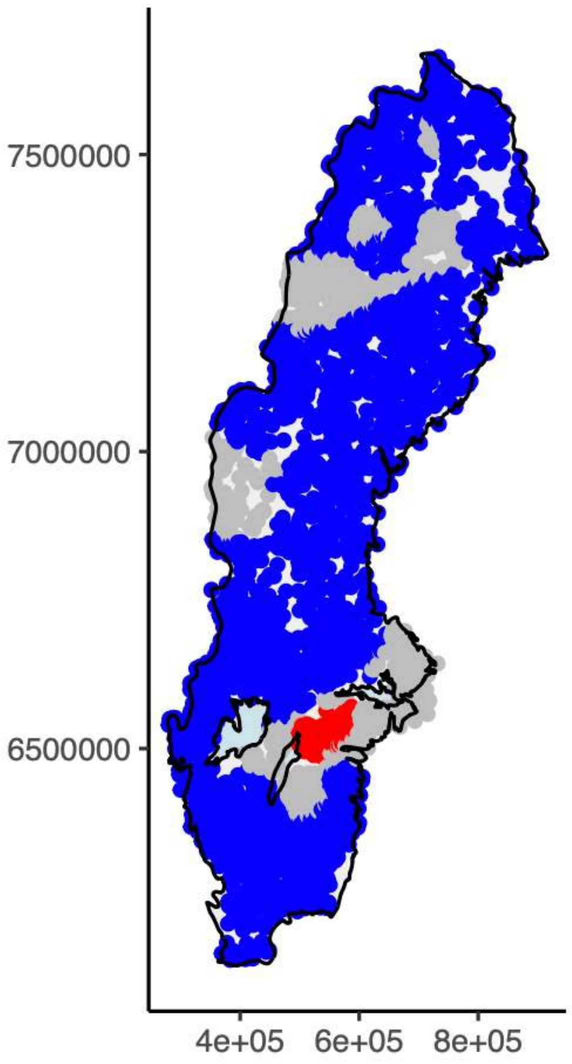
2008-2021



pH


1990
2000
2010
2020
Significant trend changes
Decreasing
None
Increasing

2008-2021

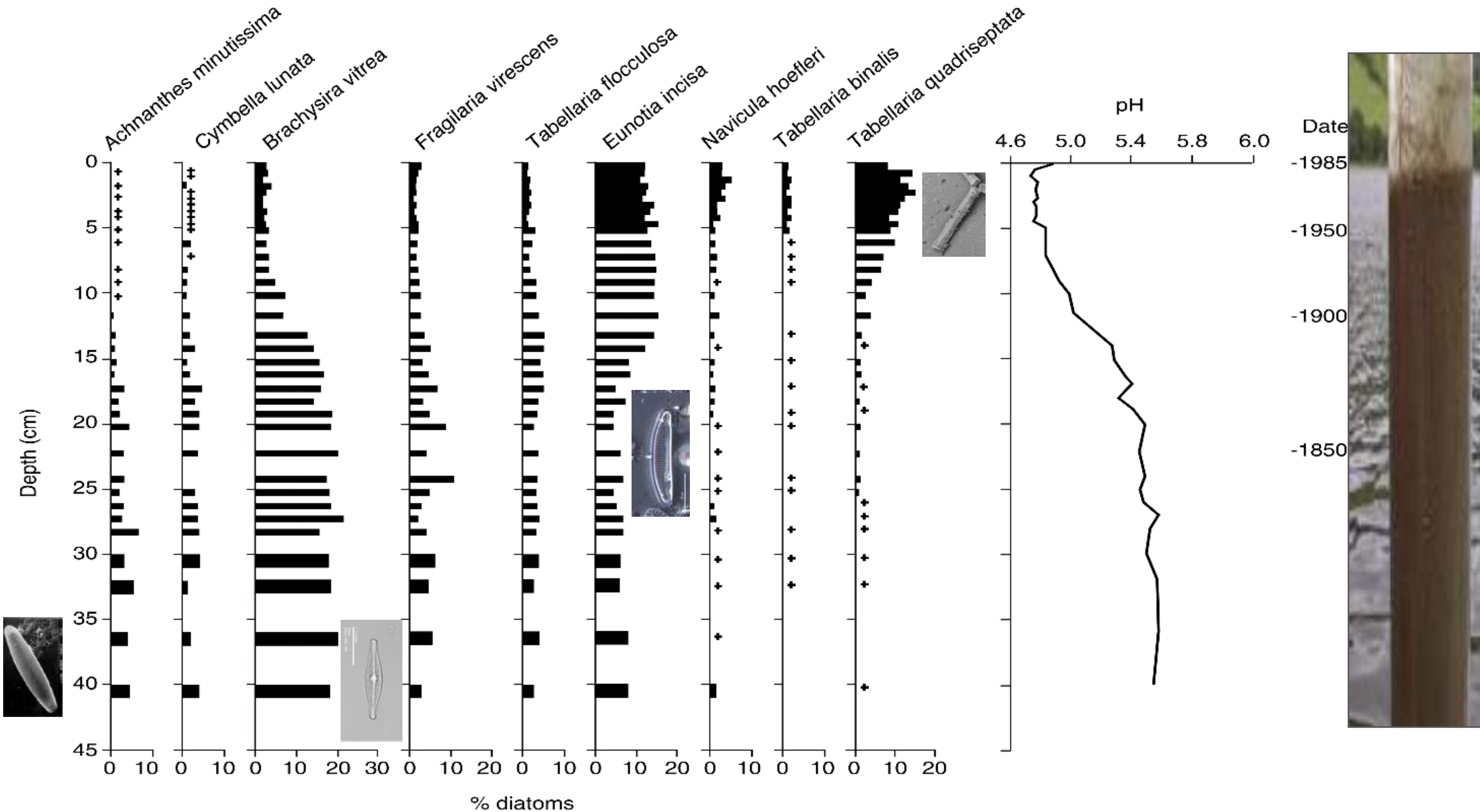

7500000
7000000
6500000
4e+05
6e+05
8e+05

30 years of recovery from acidification in the UK:

Don Monteith

UK Centre for Ecology & Hydrology

Palaeoecological analysis: definitive evidence of ecological change linked to acidification

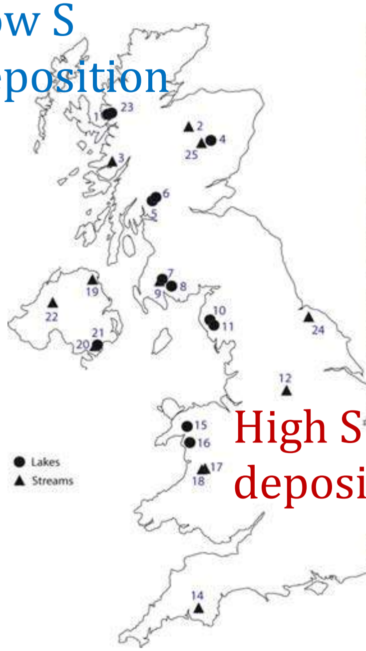


Round Loch of Glenhead

From Jones *et al*. (1990). Phil Trans Roy Soc., B, 327, 397-402.

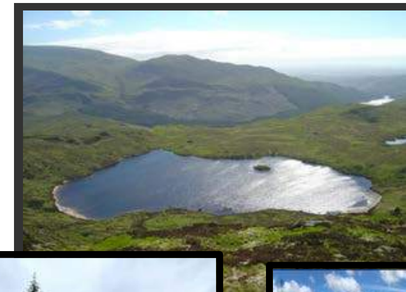
UK Centre for Ecology & Hydrology

Upland Waters Monitoring Network: Est 1988: to track impact of emission controls on sensitive lakes and stream ecosystems



1. Loch Coire nan Arr (site discontinued)
2. Allt a'Mharcaidh
3. Allt na Coire nan Con
4. Lochnagar
5. Loch Chon
6. Loch Tinker
7. Round Loch of Glenhead
8. Loch Grannoch
9. Dargall Lane
10. Scoat Tarn
11. Burnmoor Tarn
12. River Etherow
13. Old Lodge
14. Narrator Brook
15. Llyn Llagi
16. Llyn Cwm Mynach
17. Afon Hafren
18. Afon Gwy
19. Beagh's Burn
20. Bencrom River
21. Blue Lough
22. Coneyglen Burn
23. Loch Coire Fionnaraich
24. Danby Beck
25. Baddoch Burn

11 streams and 11 lakes



annual / biannual biological sampling

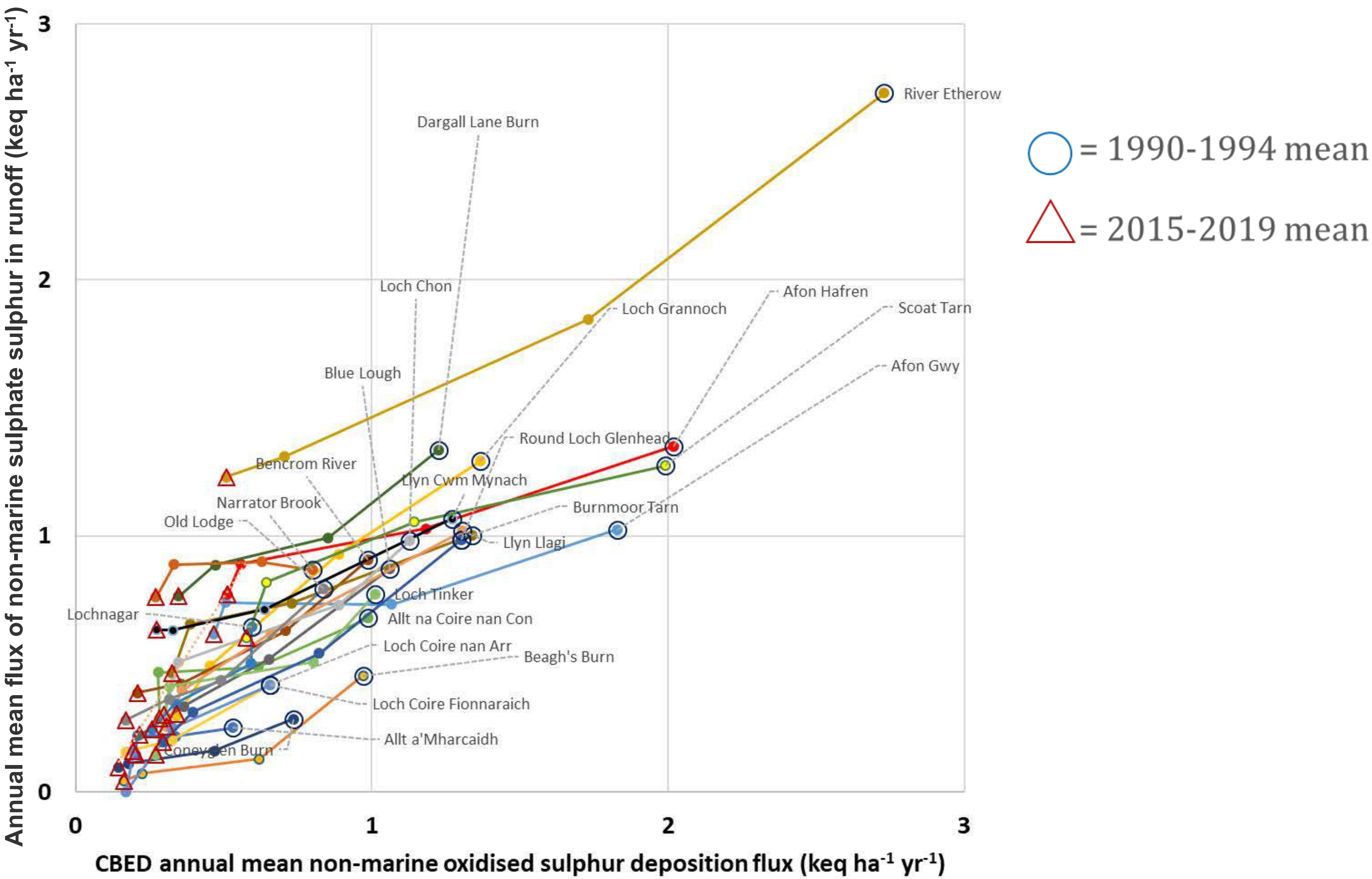
UK Centre for Ecology & Hydrology | UCL | Queen Mary University of London | marinescotland

Site photos: Ewan Shilland

After more than 30 years of monitoring…..

- How has UK upland water quality responded to reductions in acid emissions?
- Have chemical responses been sufficient to bring ANC about the UK critical limit of 20 μeq L^{-1}?
- Has water quality "flattened out"? Is more change expected?
- Have we seen ecological improvements and are these continuing?
- What are the future prospects for these ecosystems?

Linear response in sulphate flux from UWMN sites to S deposition decline – consistent with spatial relationship



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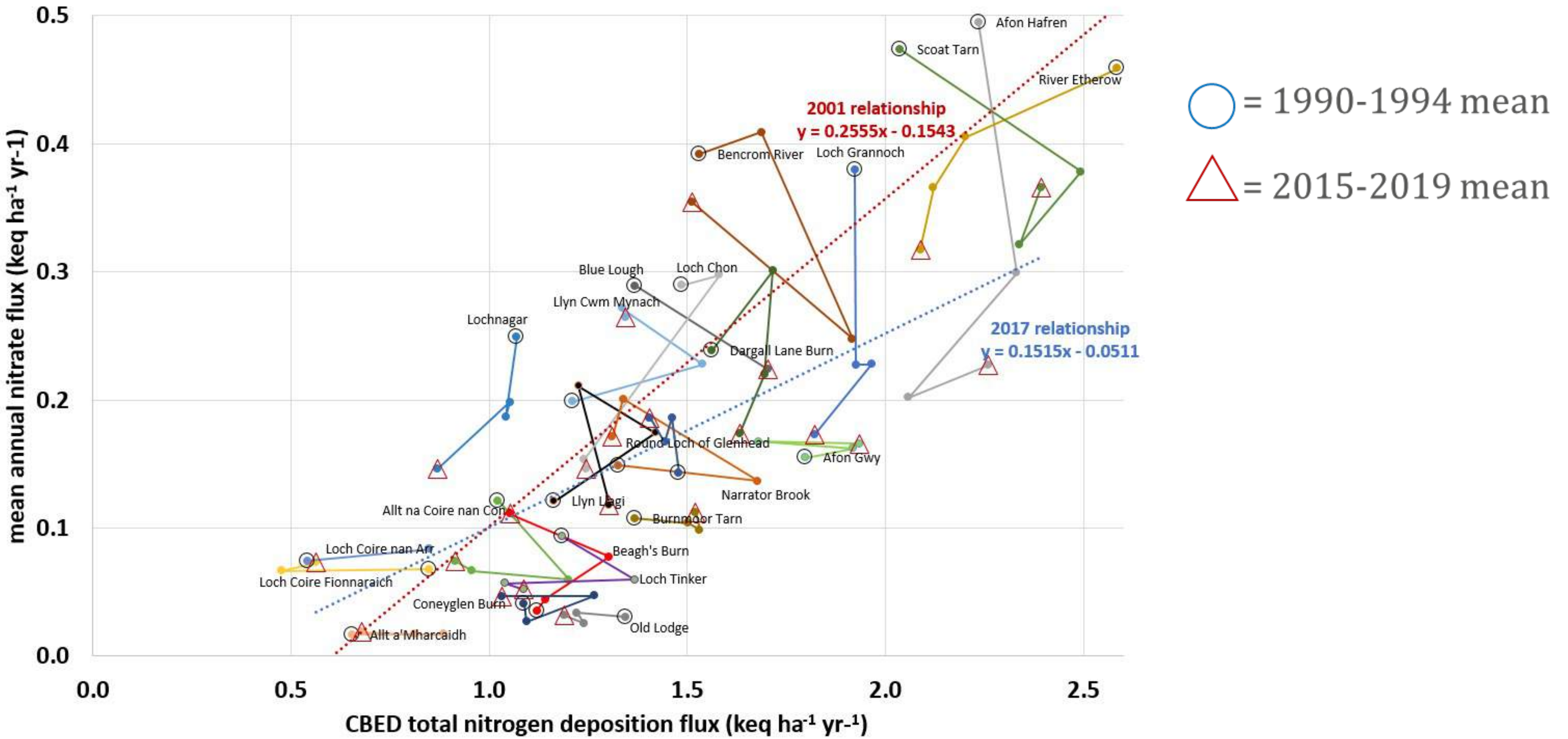
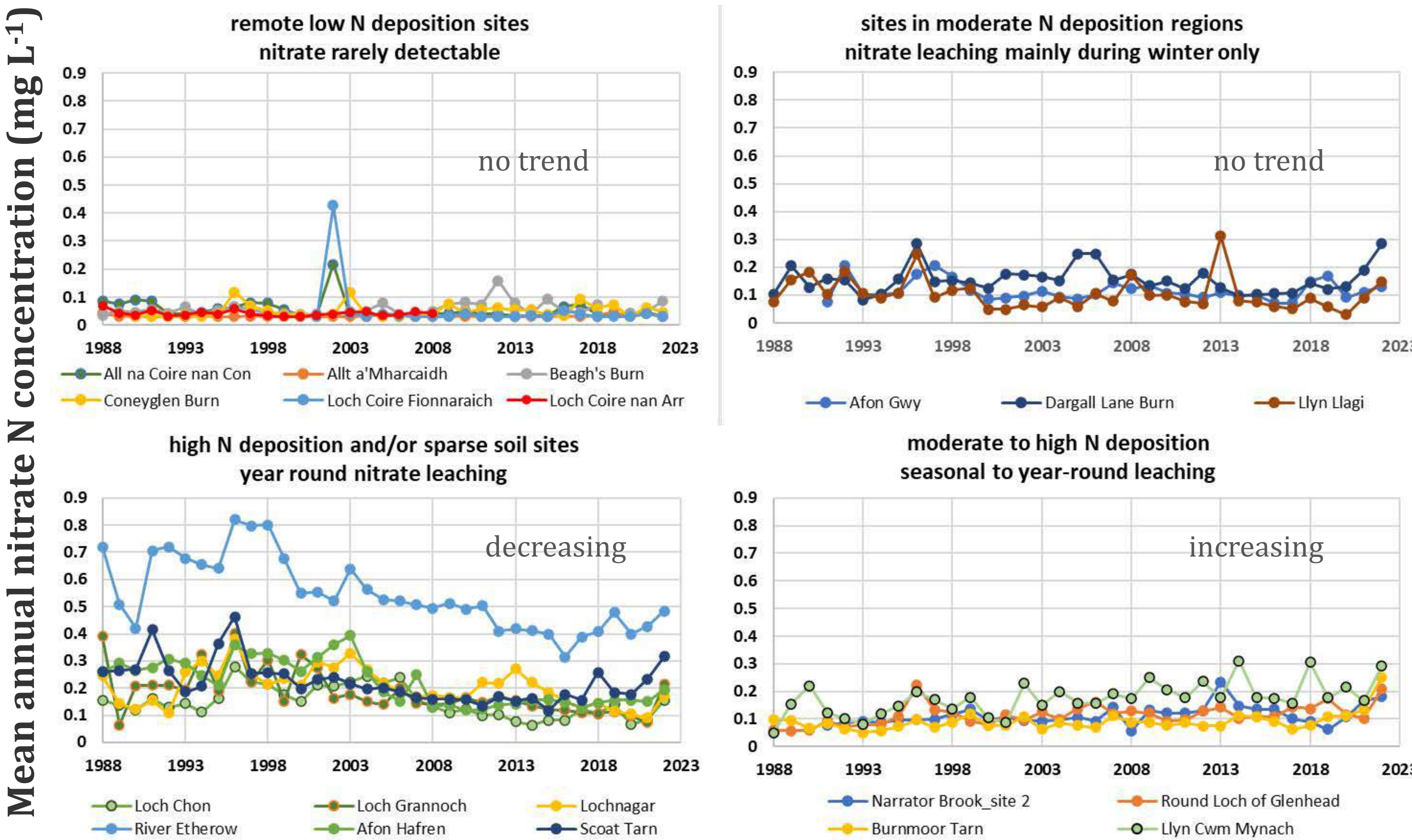
Heterogenous response in nitrate flux to N deposition decline – inconsistent with spatial relationship



UK Centre for Ecology & Hydrology

4 classes of nitrate trends



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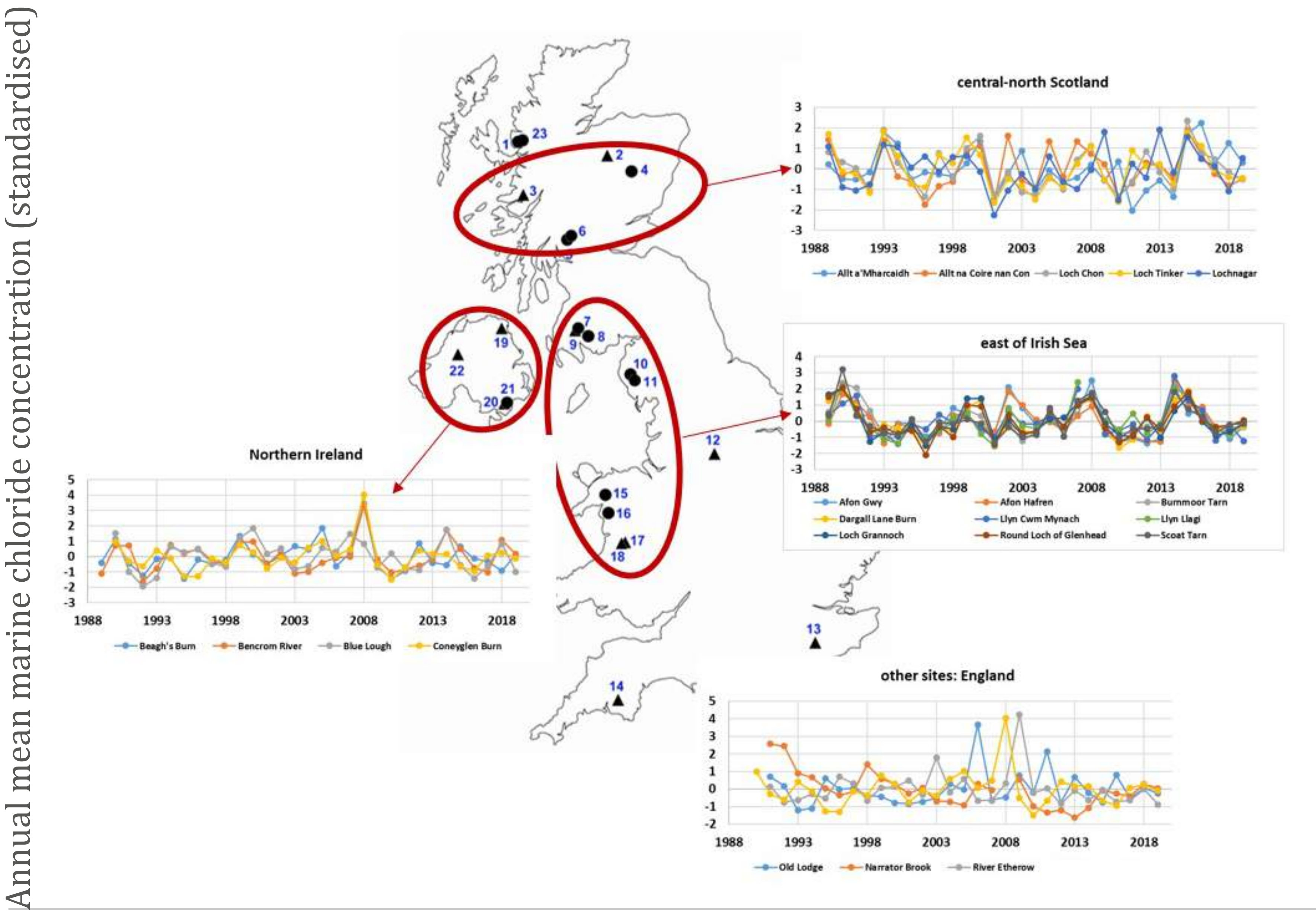
Ecology & Hydrology

4 classes of marine chloride trends



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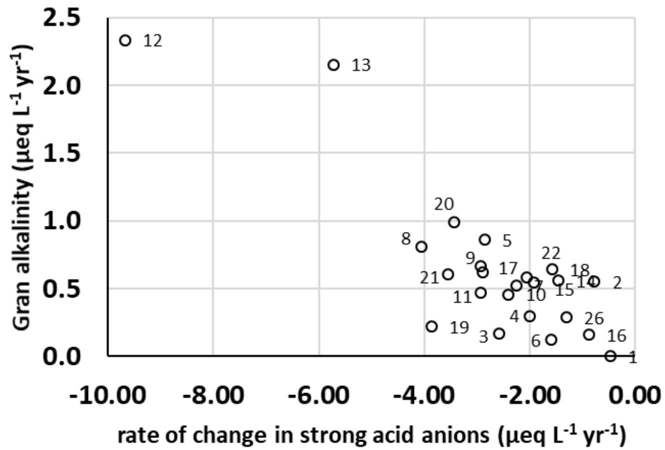
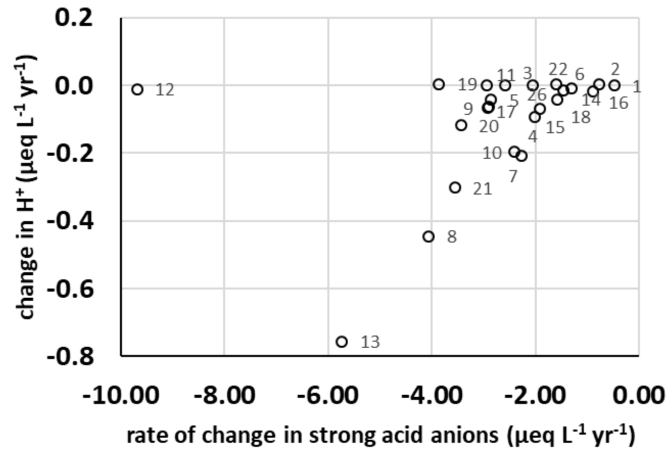
Ecology & Hydrology

Acidity metrics correlate with acid anion decline

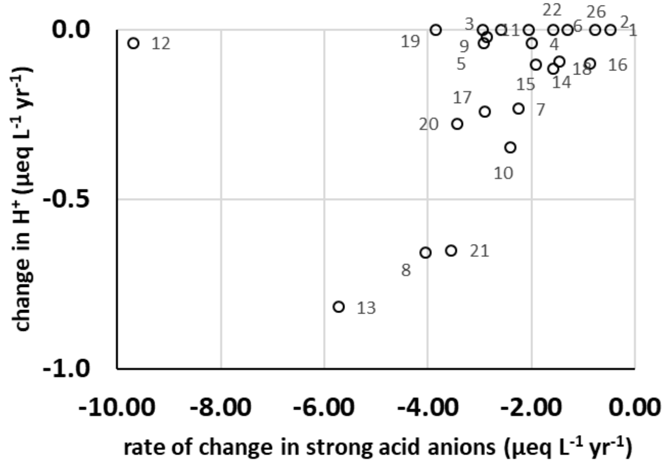
a) Gran Alkalinity trend



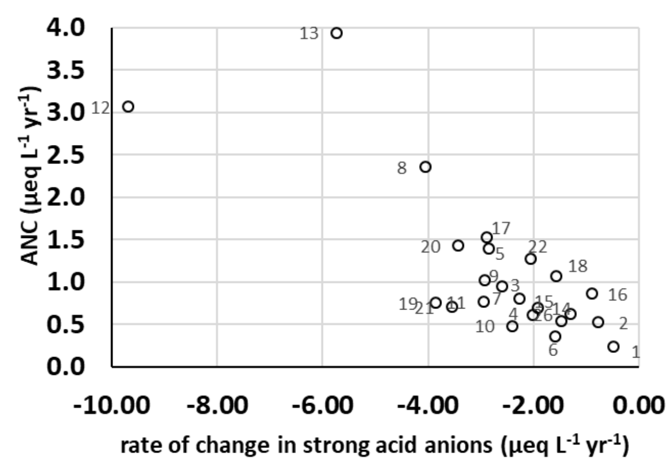
b) Hydrogen ion concentration trend



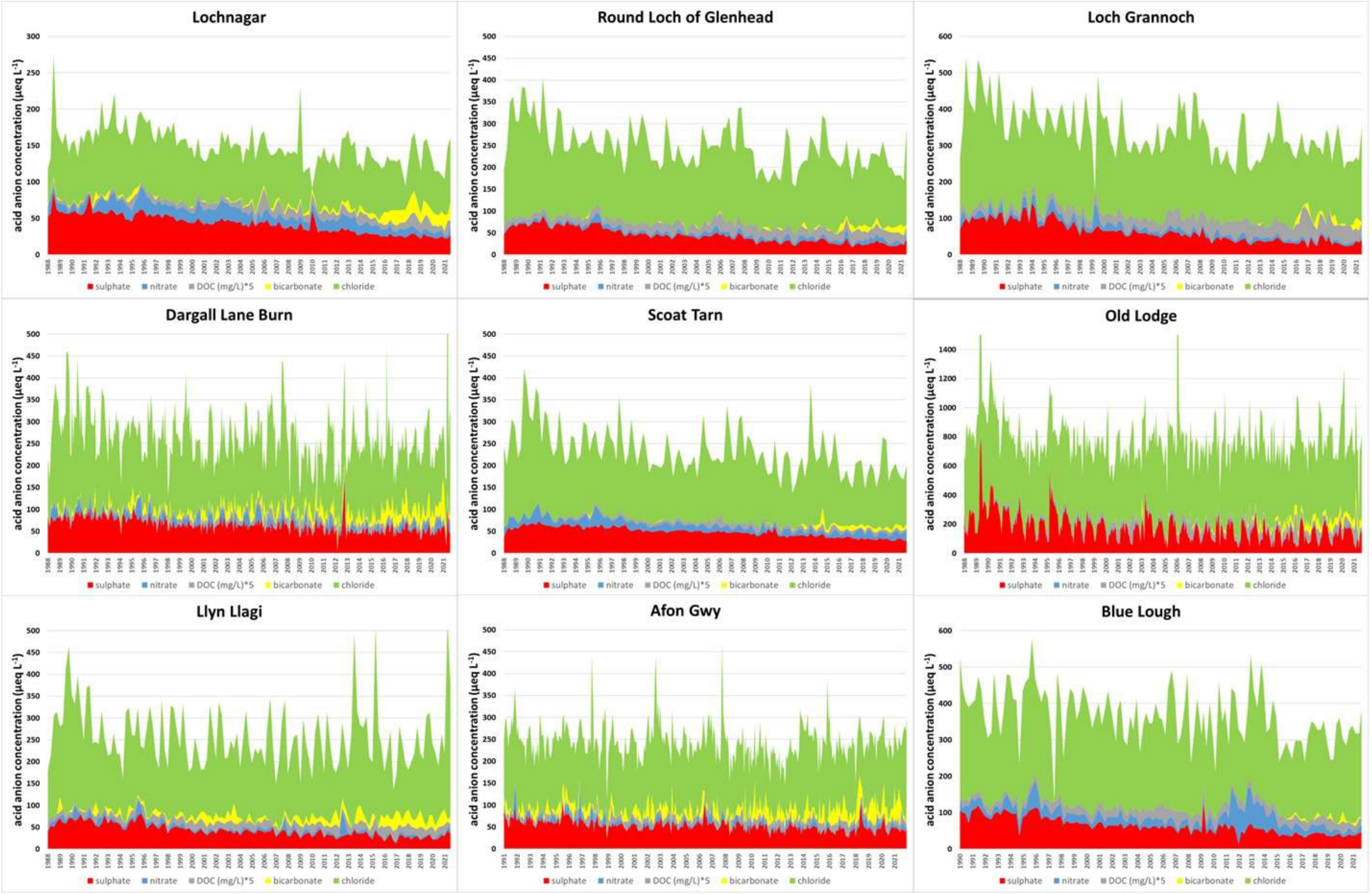
c) Labile aluminium concentration trend



d) Acid Neutralising Capacity



Bicarbonate breaking through in the most acidified waters



sulphate nitrate positive alkalinity chloride organic acidity

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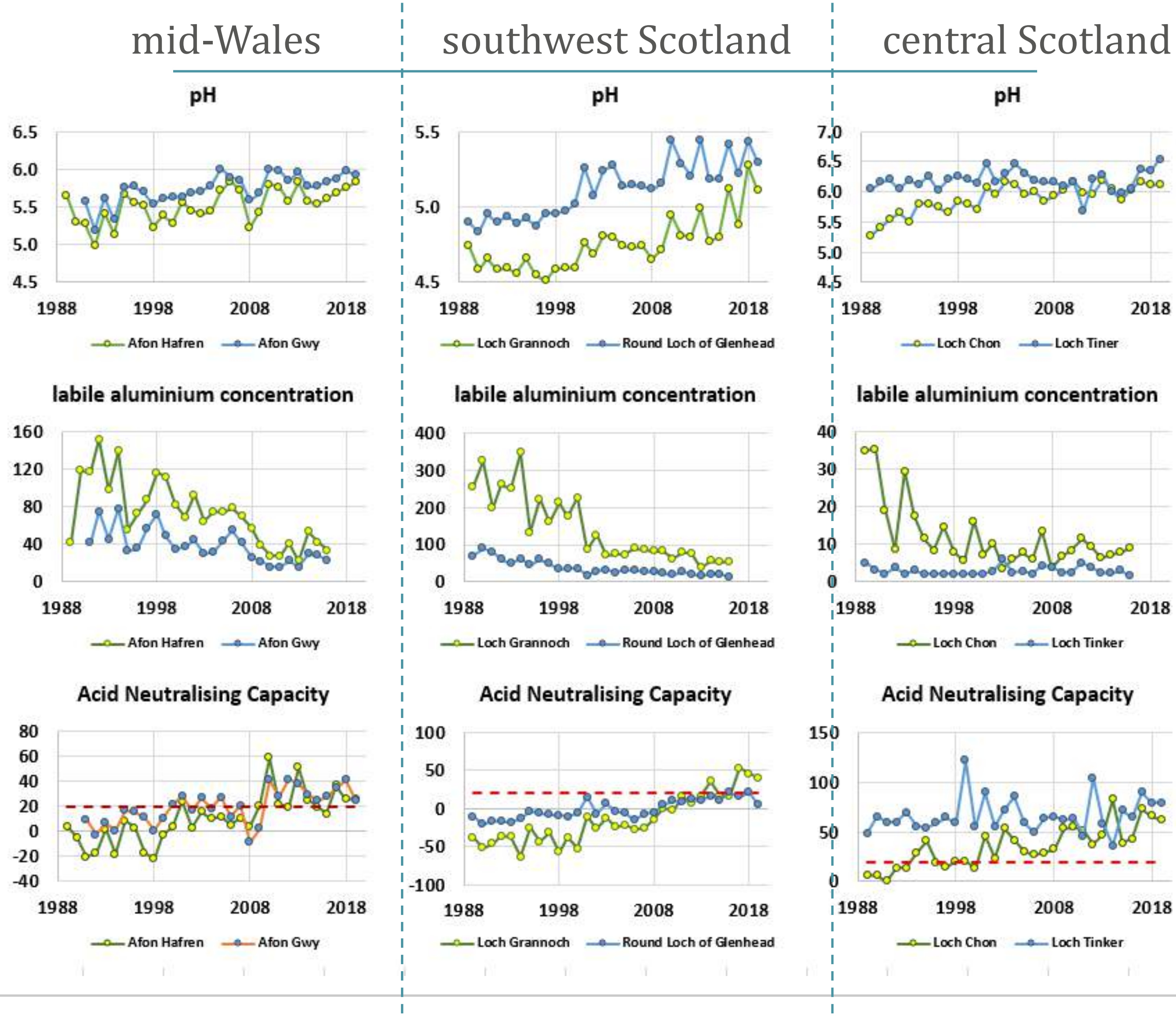
Forested sites recovering faster than moorland pairs



= 20 μeq/L ANC

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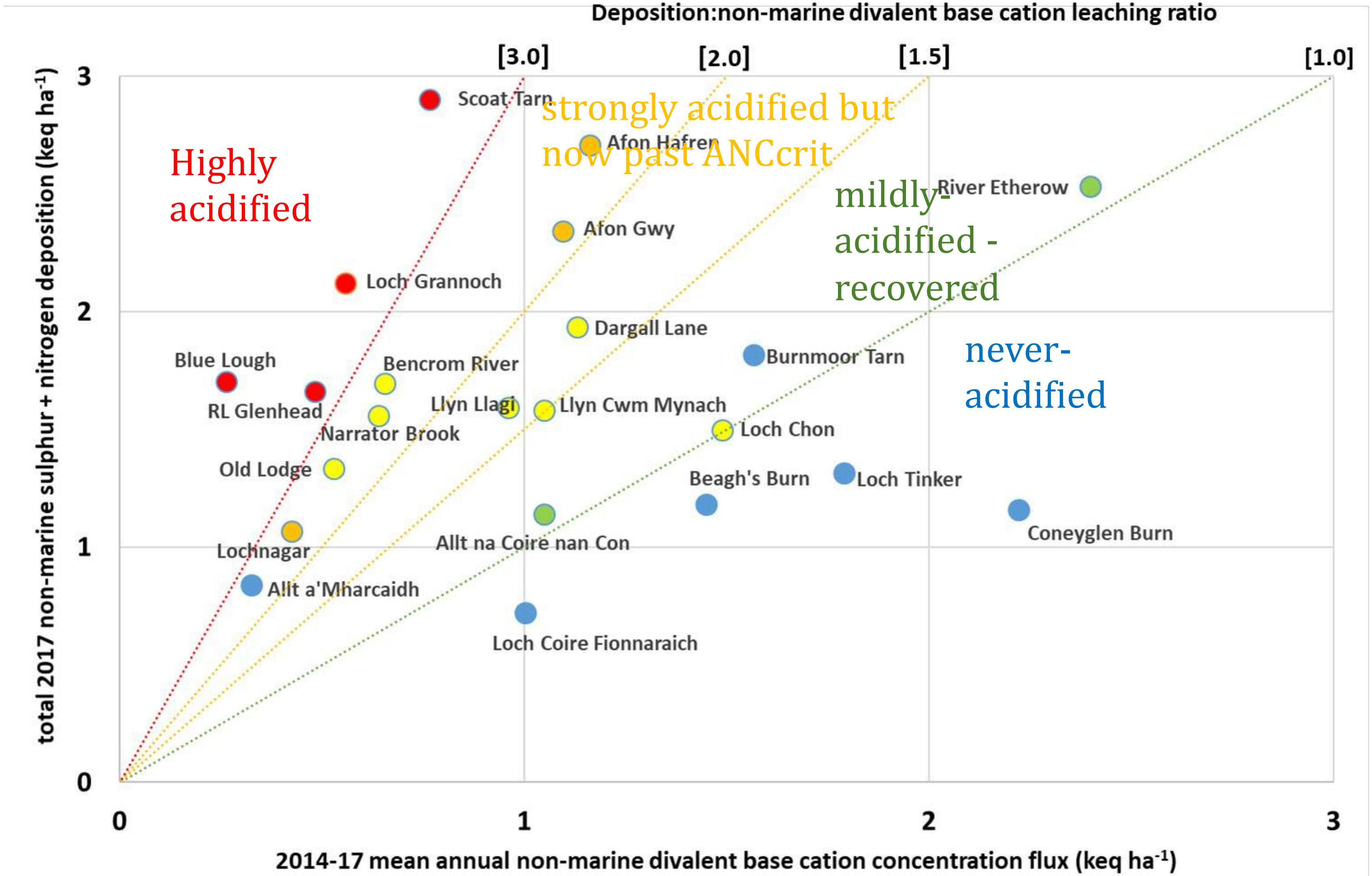
Relationship between current acid deposition and base cation generation determines chemical recovery status



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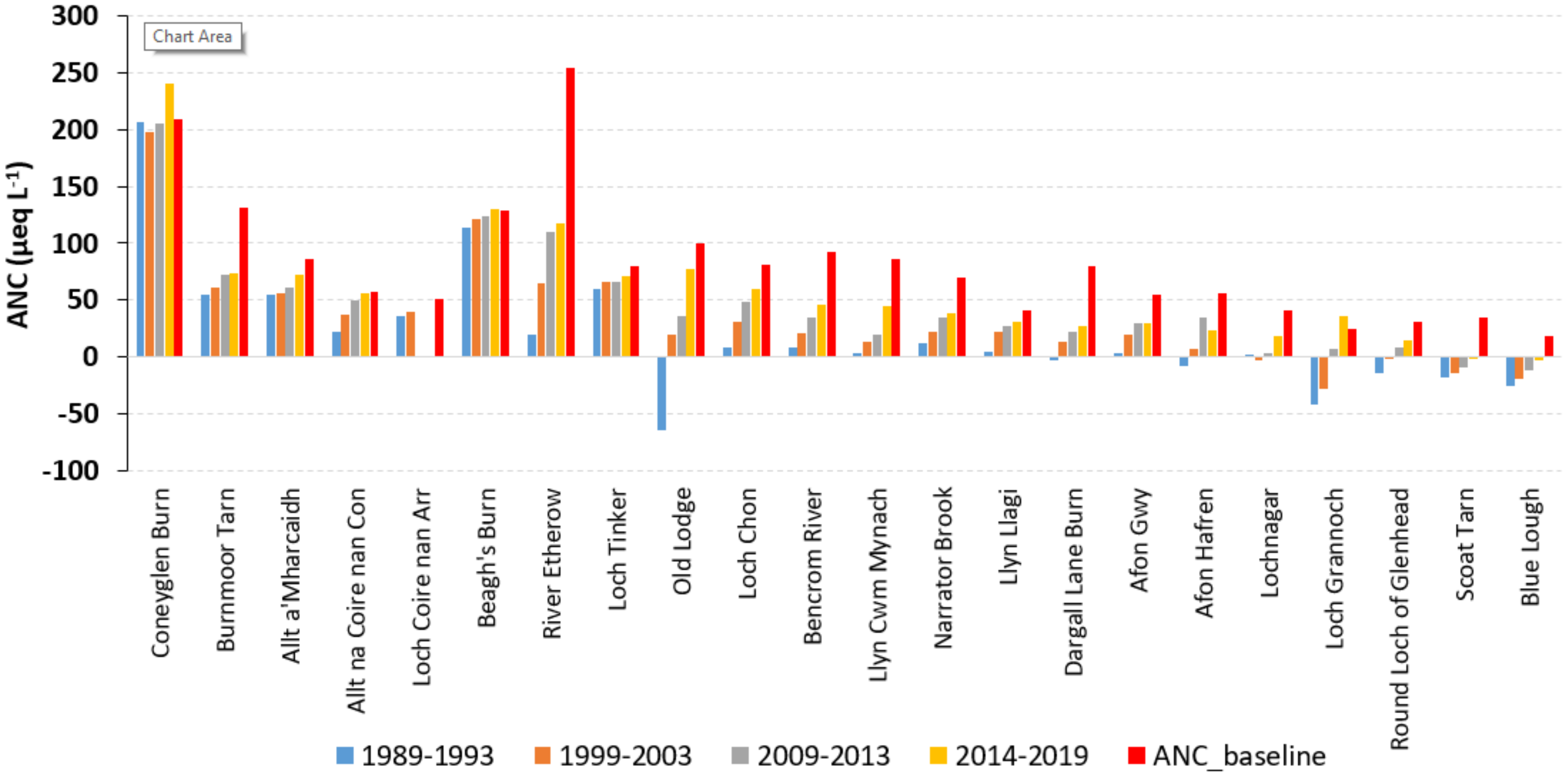
Progress to MAGIC "pre-industrial" ANC



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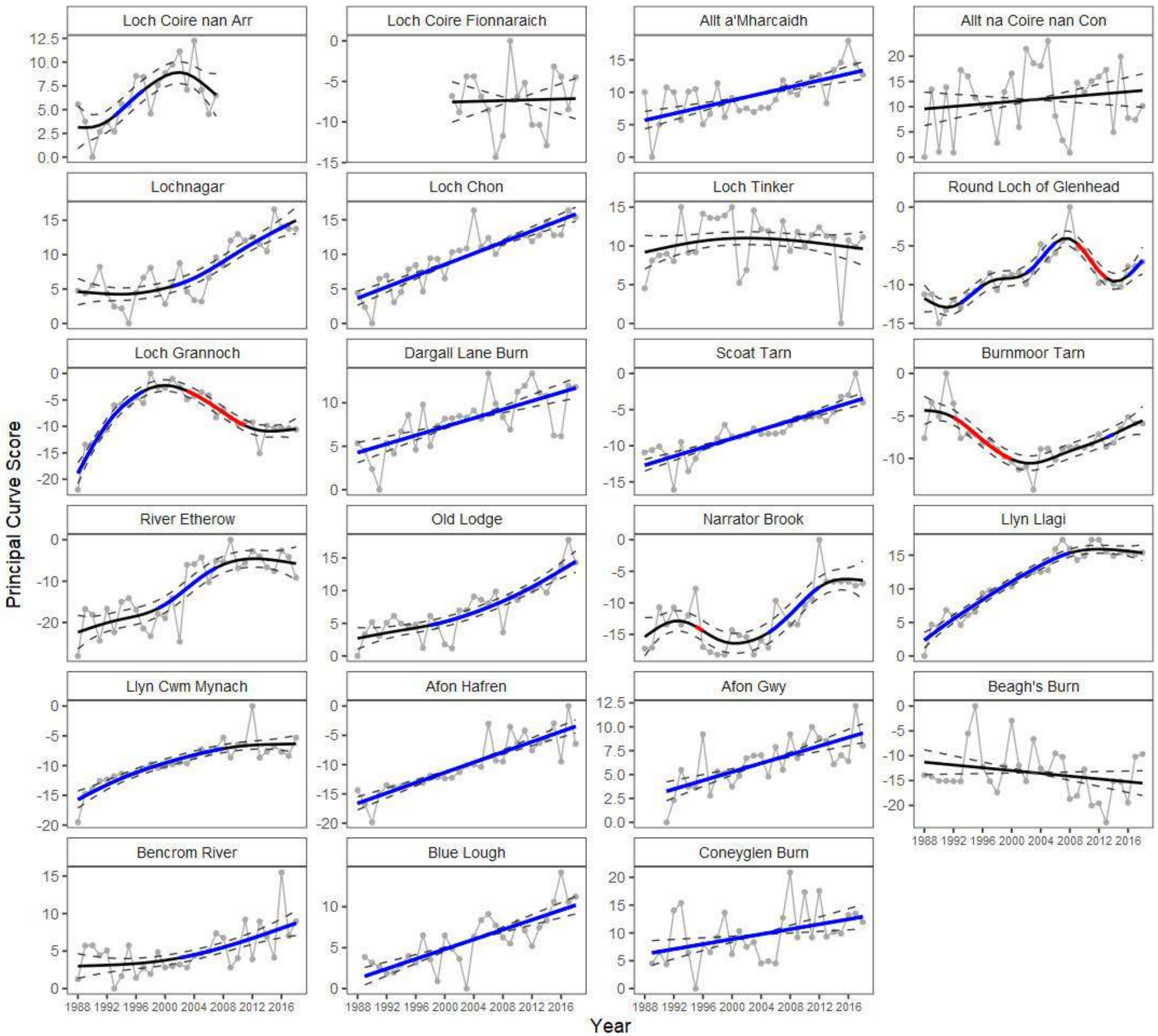
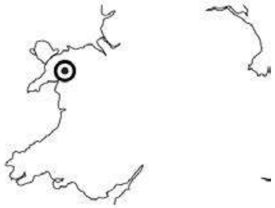
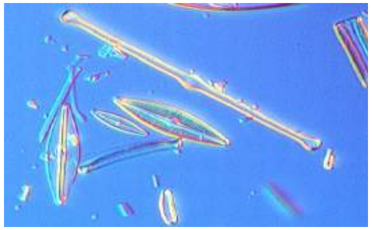
Diatom principal curves show year-by year change in species composition in almost all chemically recovering sites

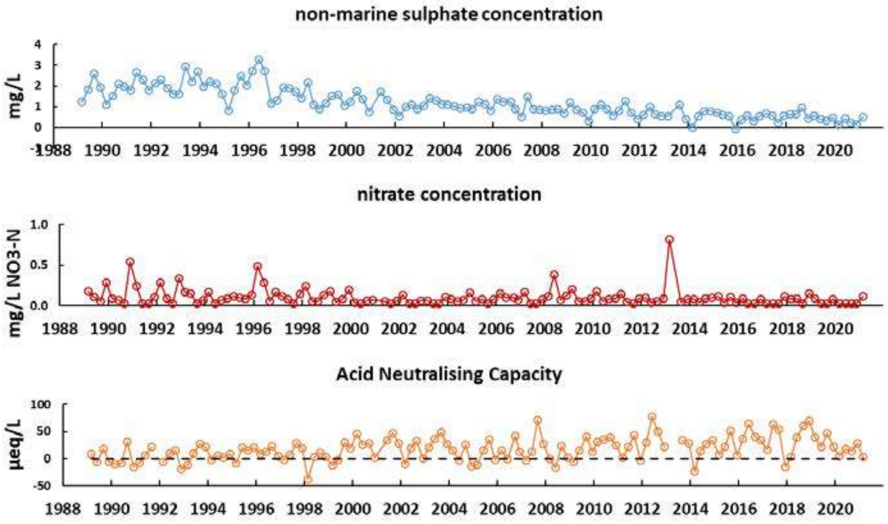


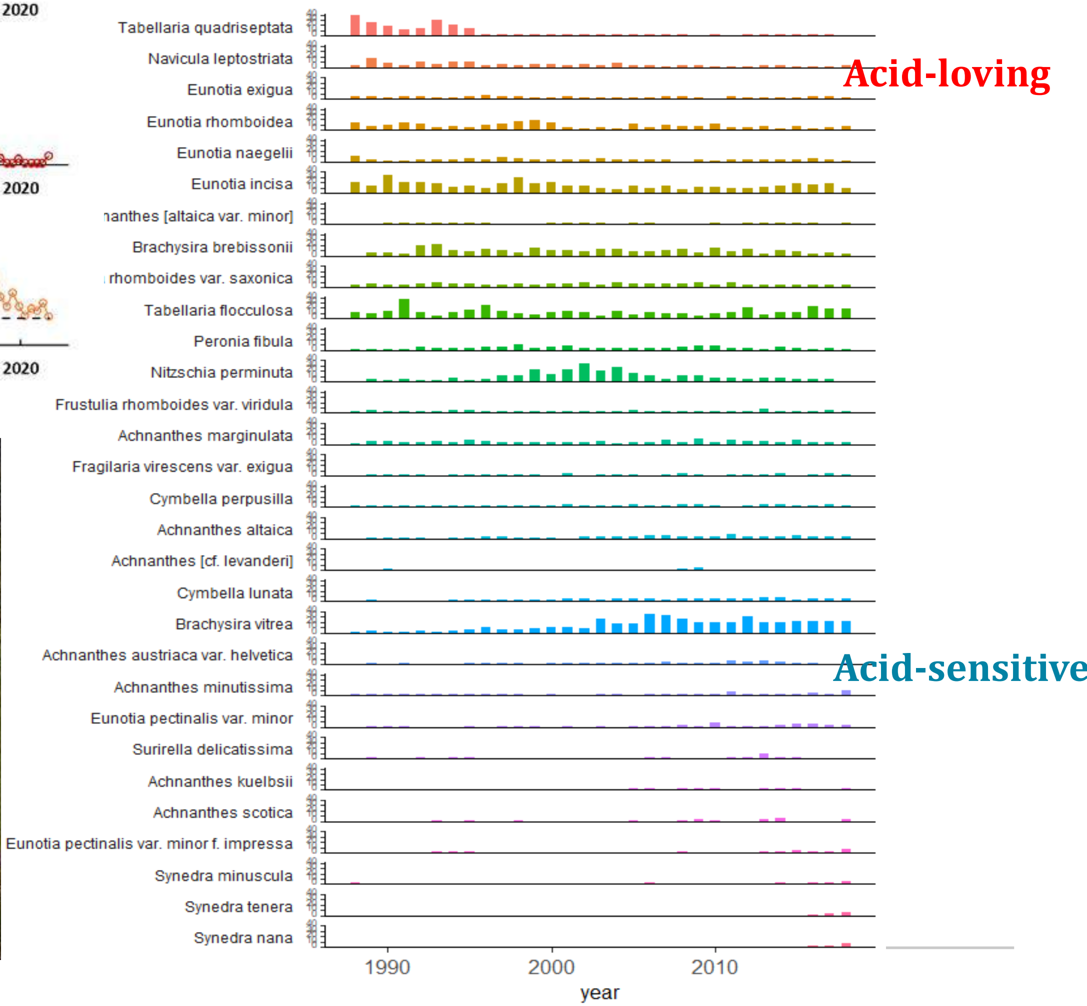
UK Centre for Ecology & Hydrology

Llyn Llagi: chemical & diatom recovery









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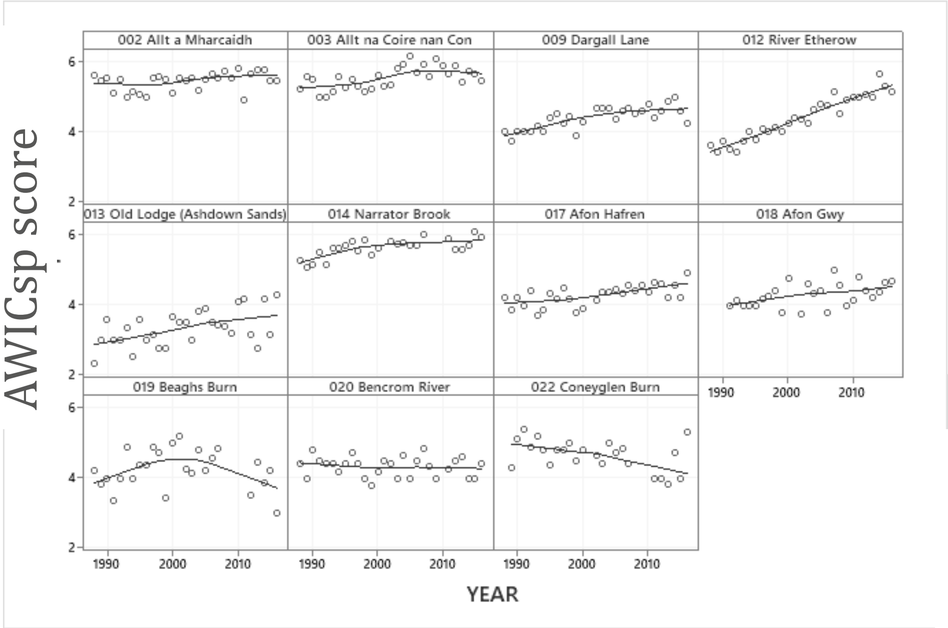
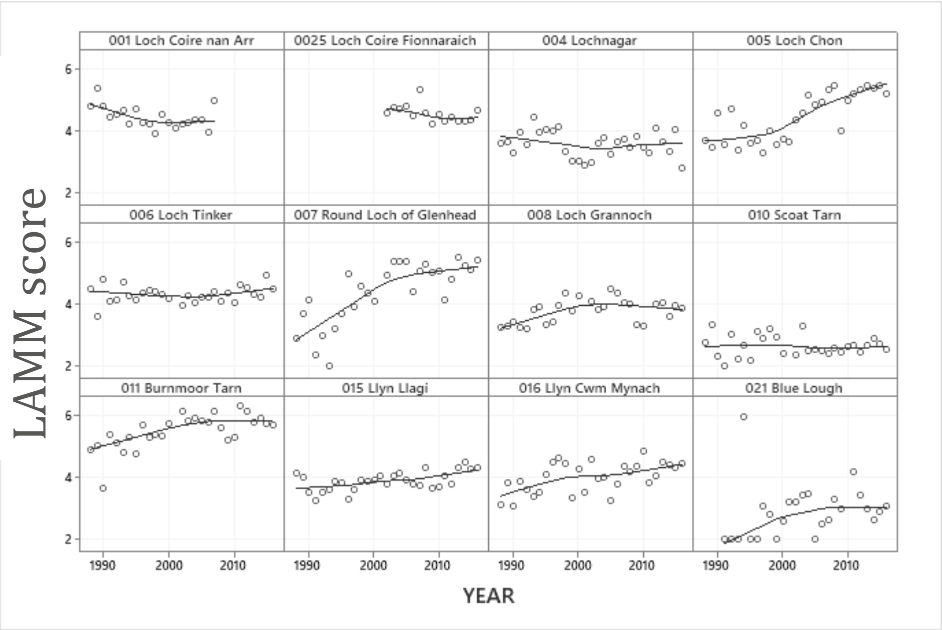
Macroinvertebrate acidification metric trends generally positive although some levelling out?

streams



lakes



species turnover and improvement in biological metrics occurring almost wherever we observe chemical recovery

		significant biological improvement?	
SITE	chemical recovery classification	DIATOMS	INVERTEBRATES
Loch Coire nan Arr	unacidified		
Loch Tinker	unacidified		
Allt a'Mharcaidh	unacidified		
Loch Coire Fionnaraich	unacidified		
Beagh's Burn	unacidified		
Burnmoor Tarn	unacidified		
Coneyglen Burn	unacidified		
River Etherow	recovering moderately acidified	✓	✓
Allt na Coire nan Con	recovering moderately acidified		✓
Narrator Brook	recovering moderately acidified		✓
Llyn Llagi	recovering moderately acidified	✓	✓
Llyn Cwm Mynach	recovering moderately acidified		✓
Dargall Lane Burn	recovering moderately acidified	✓	✓
Loch Chon	recovering moderately acidified	✓	✓
Bencrom River	recovering moderately acidified	✓	
Old Lodge	recovering moderately acidified	✓	✓
Lochnagar	recovering strongly acidified	✓	
Afon Gwy	recovering strongly acidified	✓	✓
Afon Hafren	recovering strongly acidified	✓	✓
Scoat Tarn	recovering strongly acidified		
Blue Lough	recovering strongly acidified	✓	✓
Loch Grannoch	recovering strongly acidified	✓	✓
R.Loch of Glenhead	recovering strongly acidified	✓	✓

So, are we there yet?

- Acidified lakes and streams across the UK are clearly benefitting, chemically and biologically from large reductions in acid deposition
- However, while sulphur deposition is close to “bottoming out”, concentrations of nitrate remain unnaturally high in many sites.
- In some sites current nitrate concentrations appear too high to allow waters to exceed critical limits for ANC. ANC of most sites remains way below MAGIC-inferred pre-acidification levels.
- Elevated nitrate concentrations also likely to be influencing within lake biogeochemical processes and ecosystem structure.
- The return of acid-sensitive algal and macroinvertebrate populations suggest highly dynamic responses to chemical improvements – little evidence of major lags
- Future freshwater ecological dynamics will become increasingly dominated by climate variation and change

acknowledgements

UWMN

Chris Evans, Dave Norris, Iain Gunn, Andy Sier, The Lancaster UKCEH Chemistry Facility, Ewan Shilland (UCL), Simon Patrick (UCL), Rick Battarbee (UCL), Iwan Jones (QMUL), John Murphy (QMUL), Steve Juggins (University of Newcastle)

Defra, Welsh Government, NRW, Nature Scot, Forest Research, UCL-ECRC, QMUL, Marine Scotland, DAERA, SEPA, EA.

DOC/Acidification Interactions in Sudbury, Canada

John Gunn
Haley Moskal
Brie Edwards

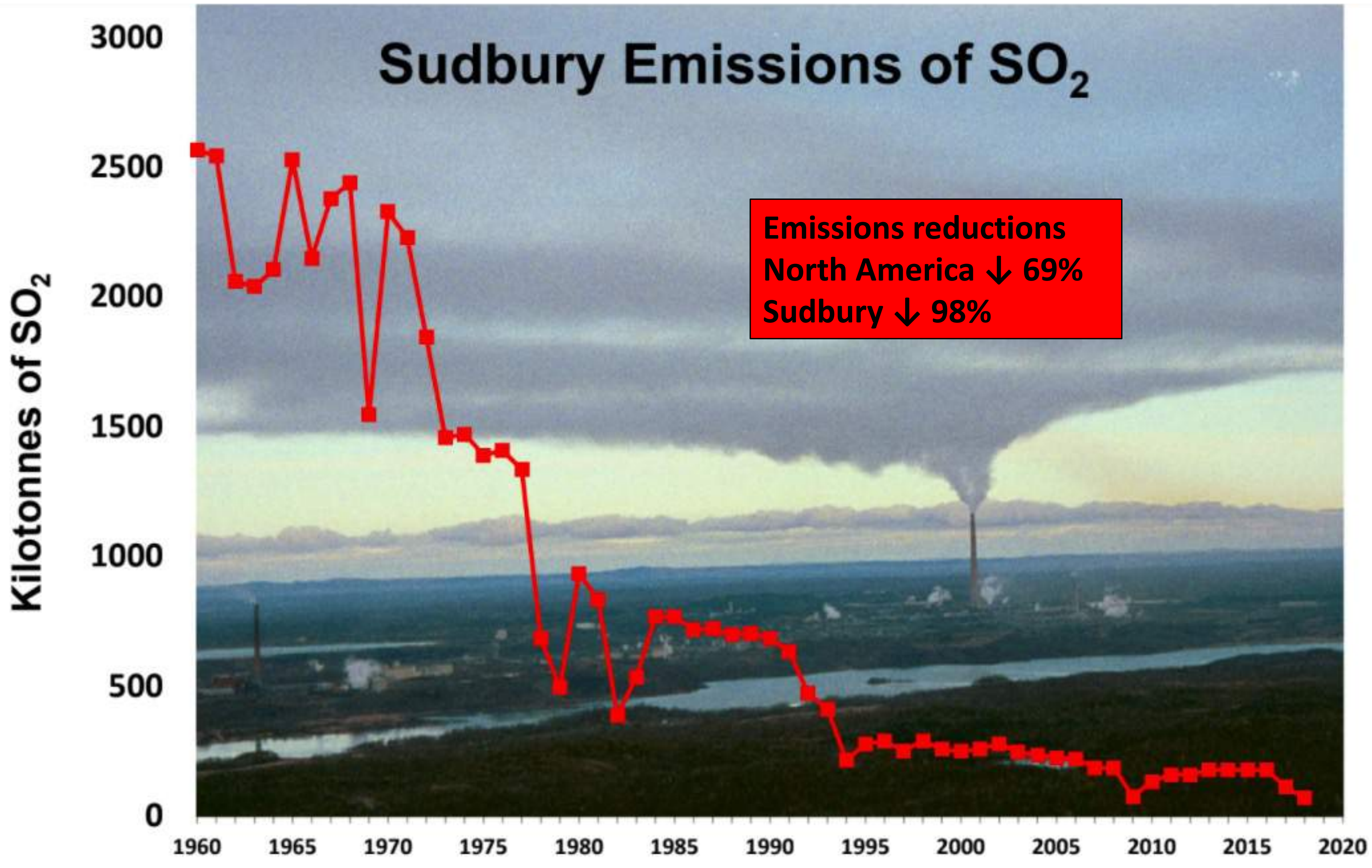
Laurentian University
jgunn@laurentian.ca

Histor
Impac
(cir

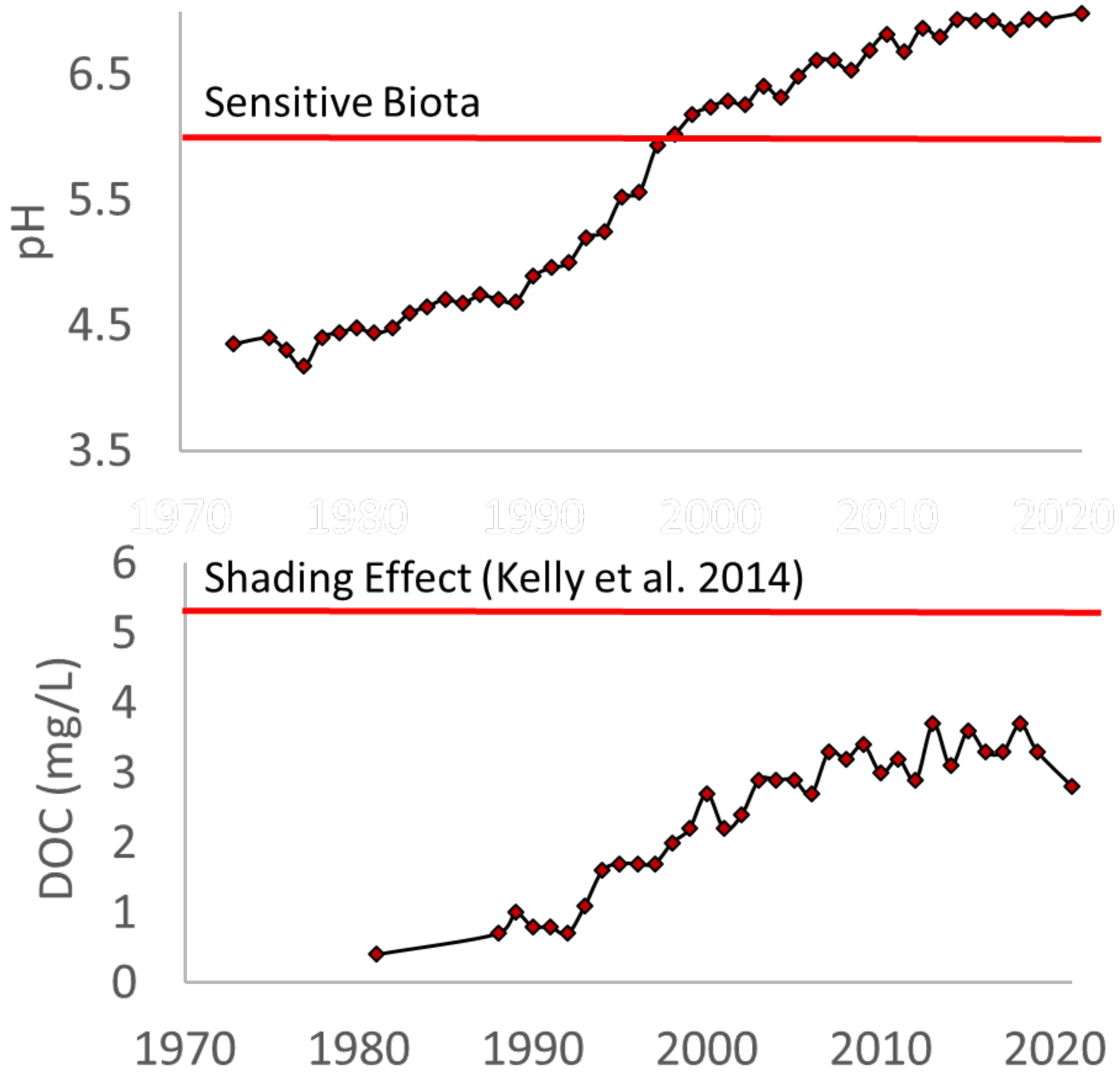
Acidificat
in a 1

89,000

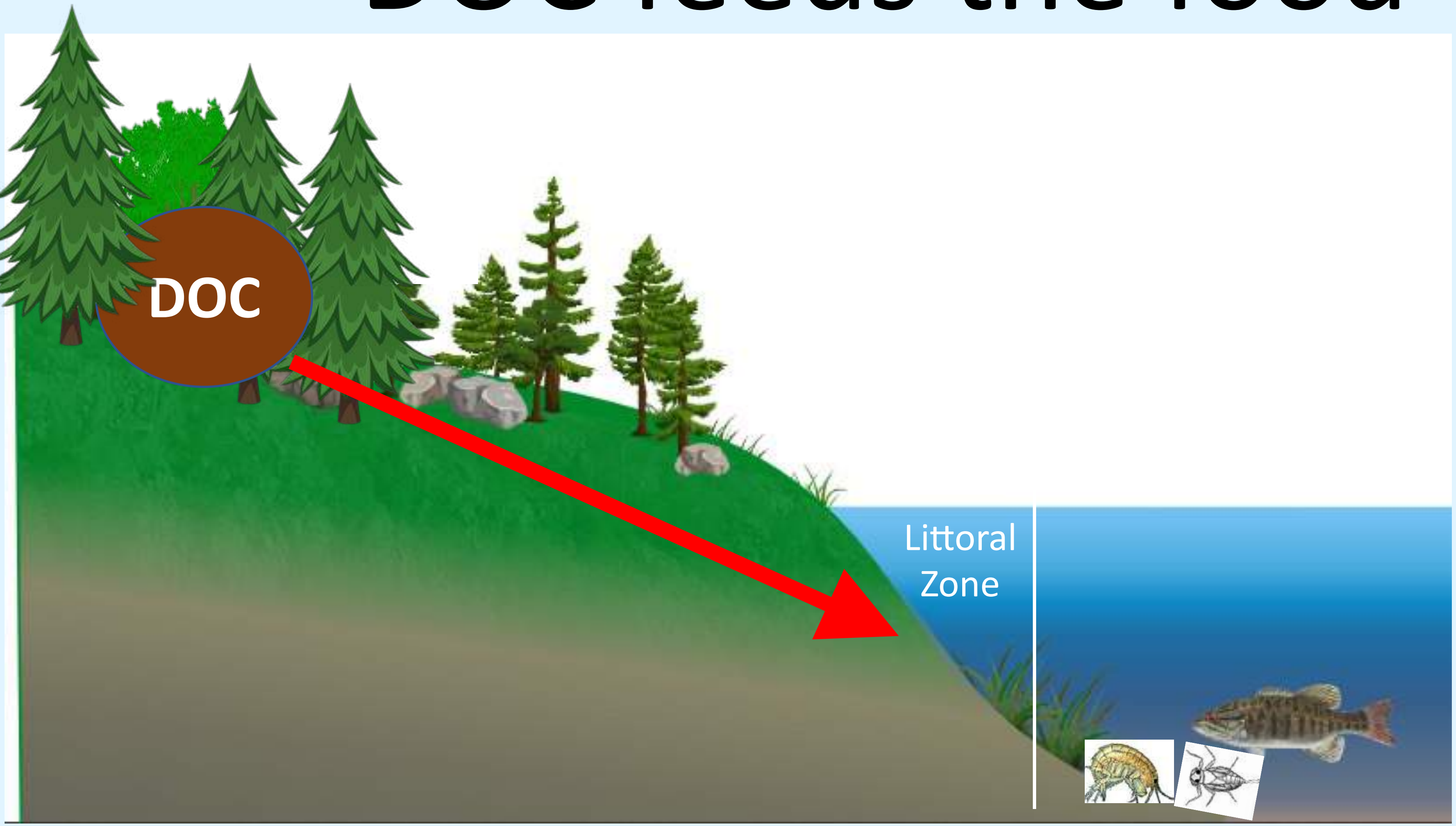
89 Lake

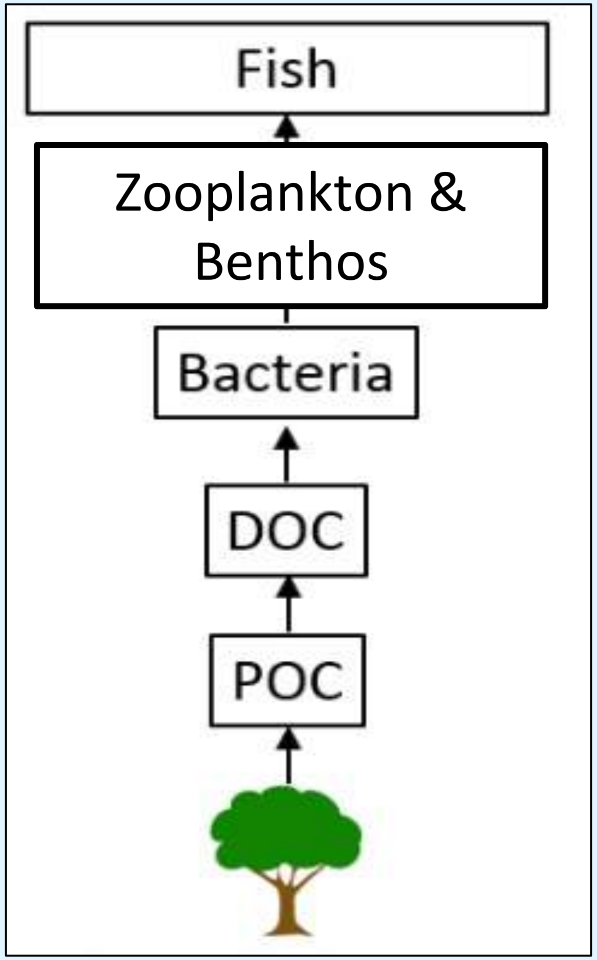

Sudbury Emissions of SO_2
Emissions reductions
North America ↓ 69%
Sudbury ↓ 98%
Kilotonnes of SO_2
3000
2500
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

Clearwater Lake: Our Longest Running Monitoring Lake



DOC feeds the food web





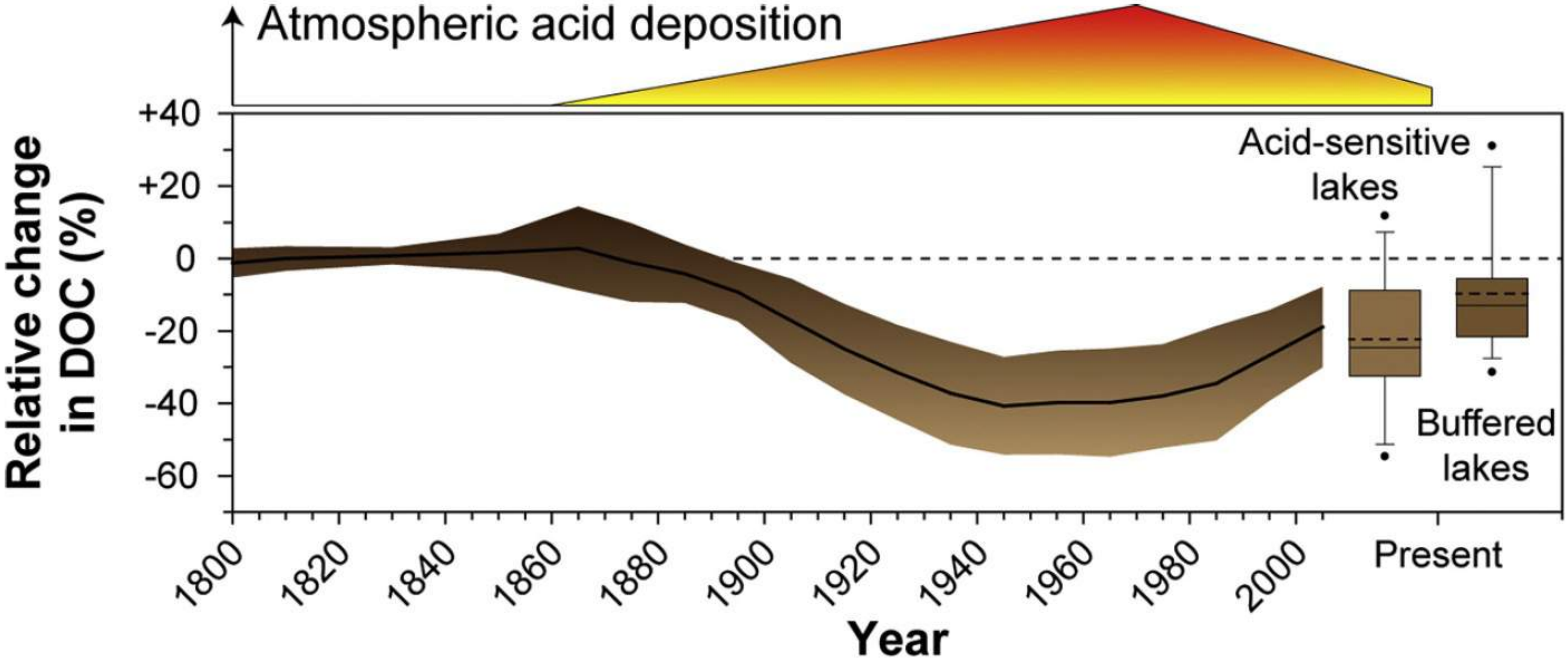
nature COMMUNICATIONS
Received 29 Nov 2013 | Accepted 9 May 2014 | Published 11 Jun 2014
DOI: 10.1038/ncomms5077
OPEN

Forests fuel fish growth in freshwater deltas

Andrew J. Tanentzap[1,†], Erik J. Szkokan-Emilson[1], Brian W. Kielstra[2], Michael T. Arts[3,†], Norman D. Yan[4,5] & John M. Gunn[1]

Paleo Reconstructions

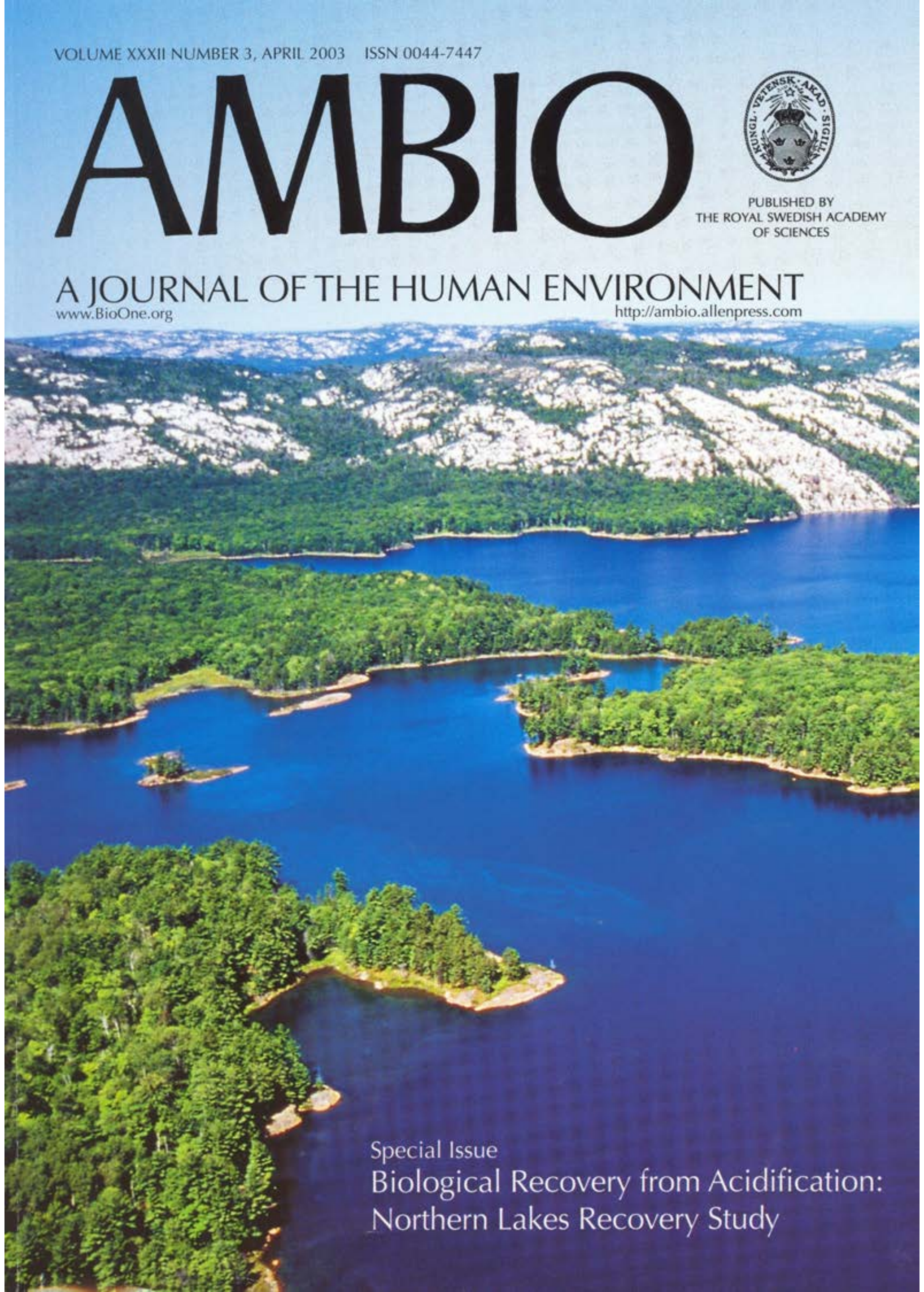
Re-browning of Sudbury (Ontario, Canada) lakes now approaches pre-acidification DOC levels



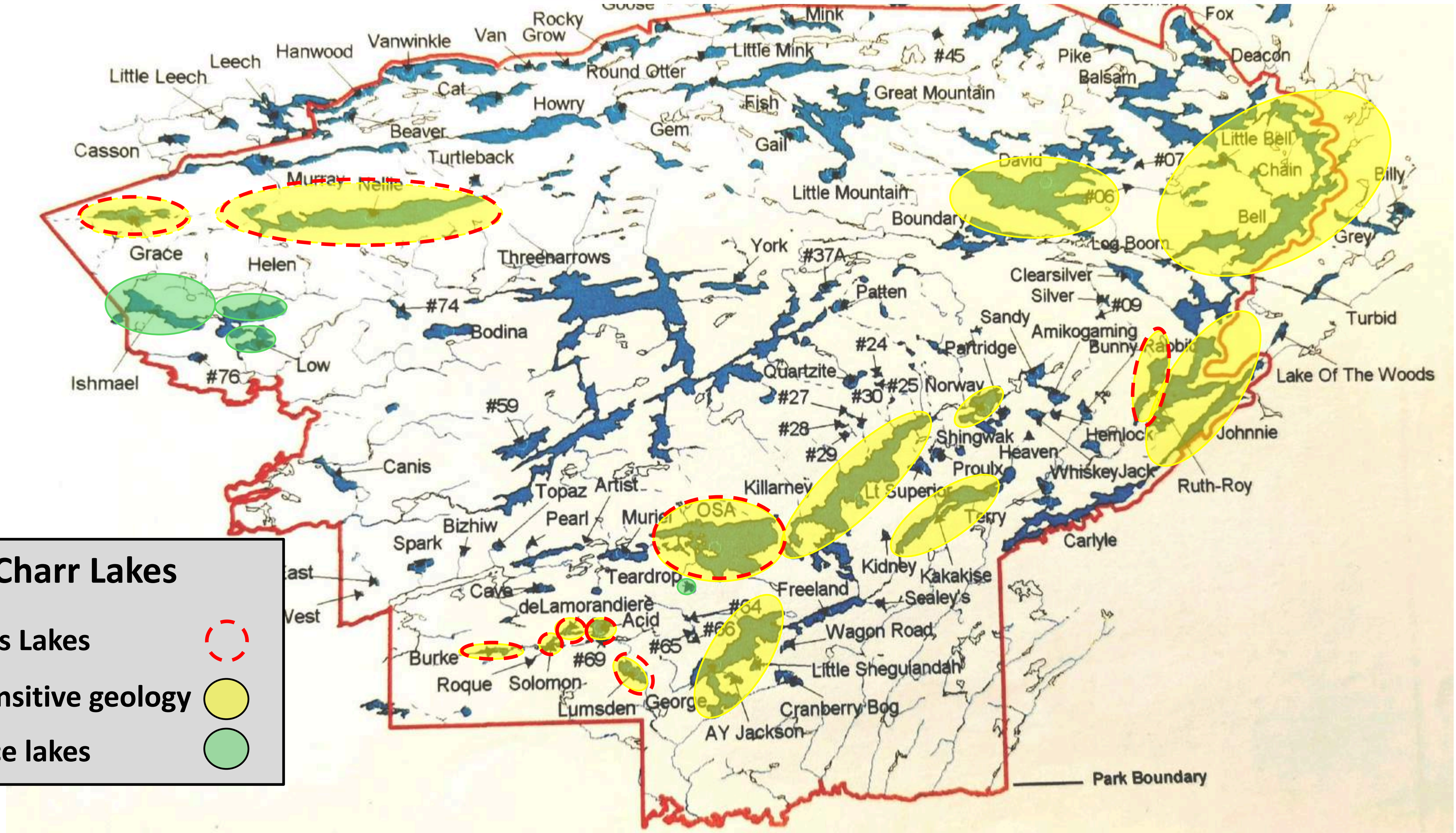
Carsten Meyer-Jacob et al. 2020 Sci. Total Env.

Killarney Provincial Park

- Home of ultra-clear lakes
  DOC < 1mg/L
- Approximately 50,000 ha
- Canada's original acidification study site (Beamish and Harvey 1972)
- Canada/Norway Collaborative Study (1997-2002)



Biodiversity Reassessment (1995 vs 2022)



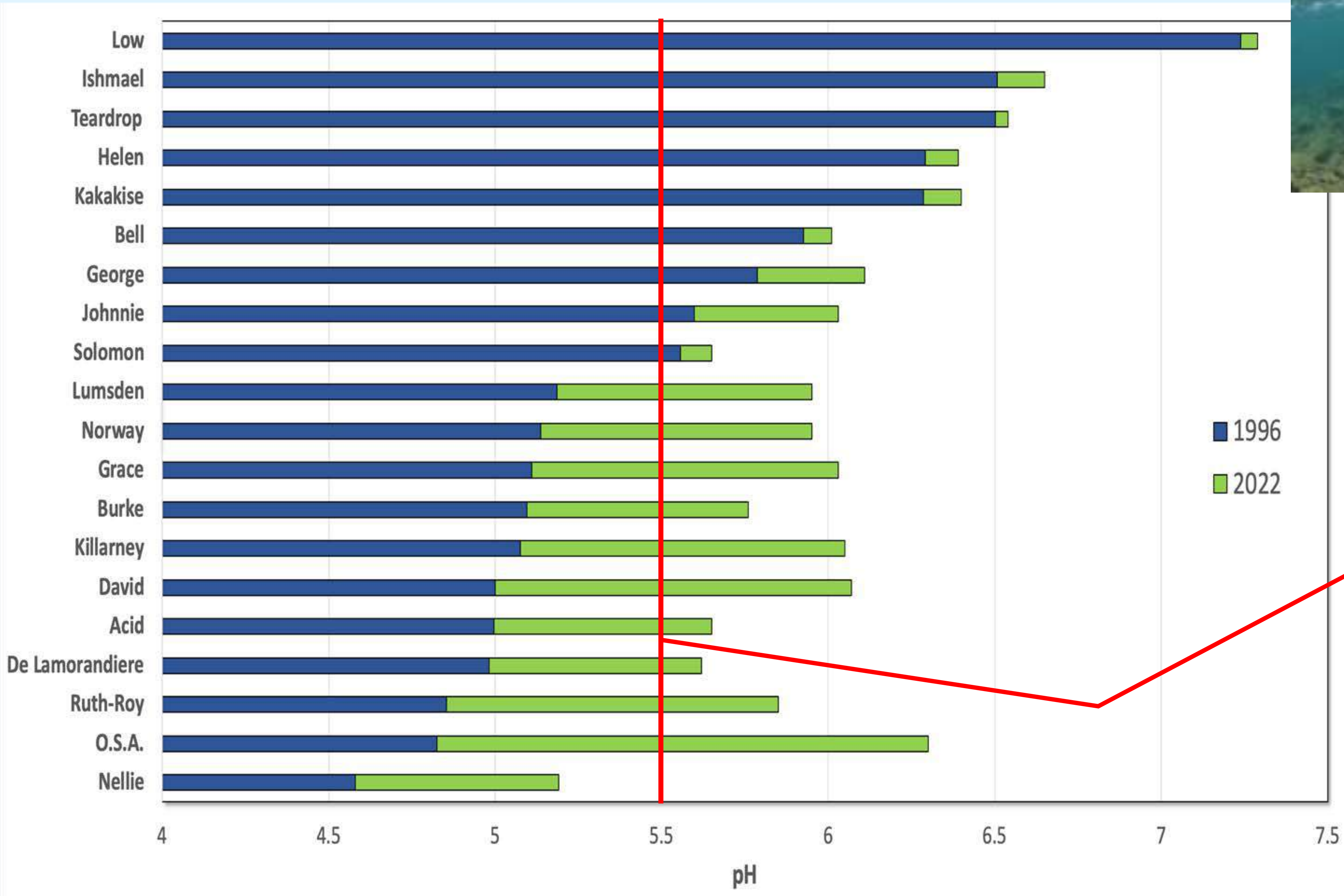
20 Lake Charr Lakes

9 Fishless Lakes

16 Acid sensitive geology

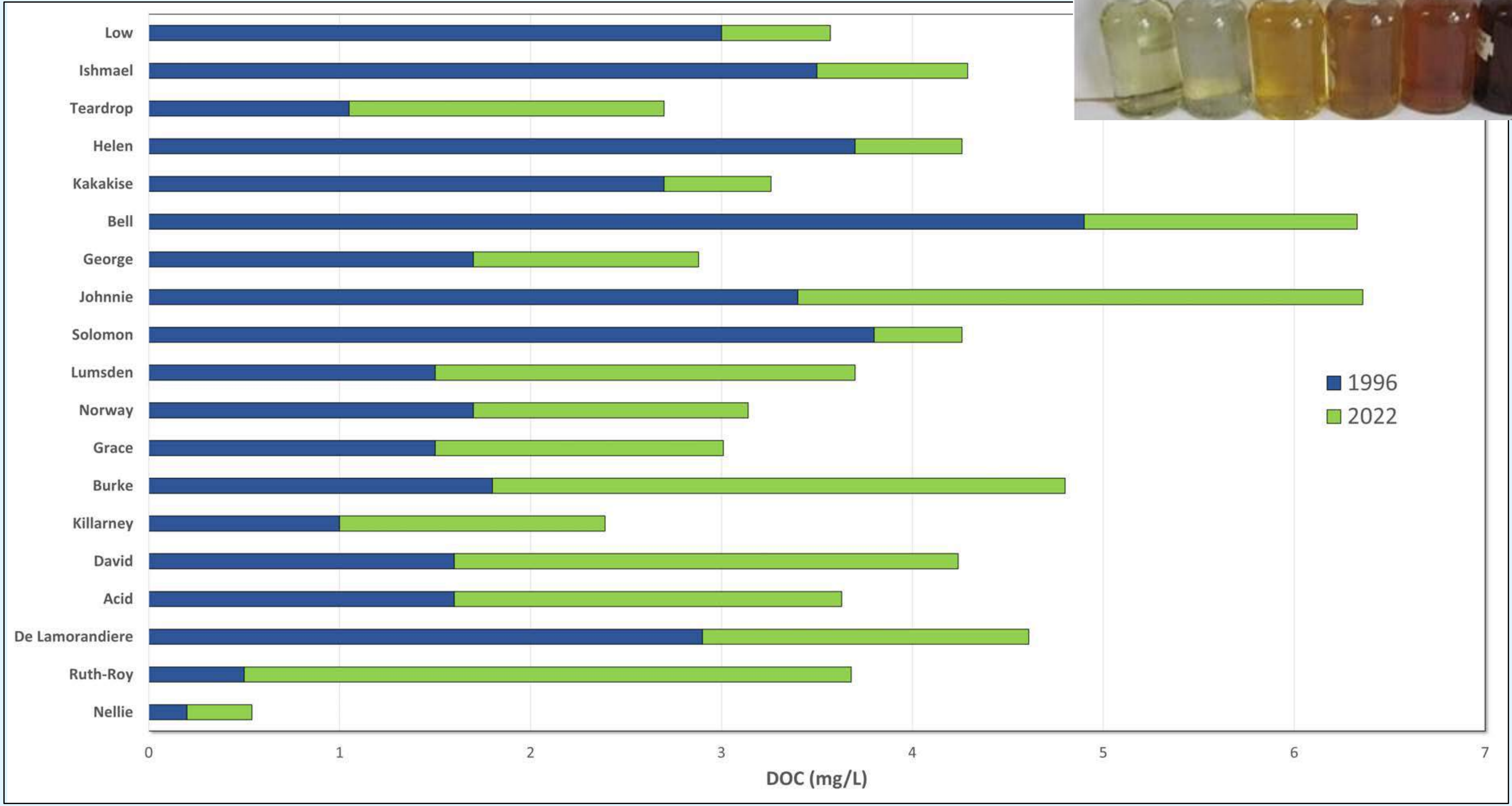
4 Reference lakes

pH recovery of Lake Charr lakes

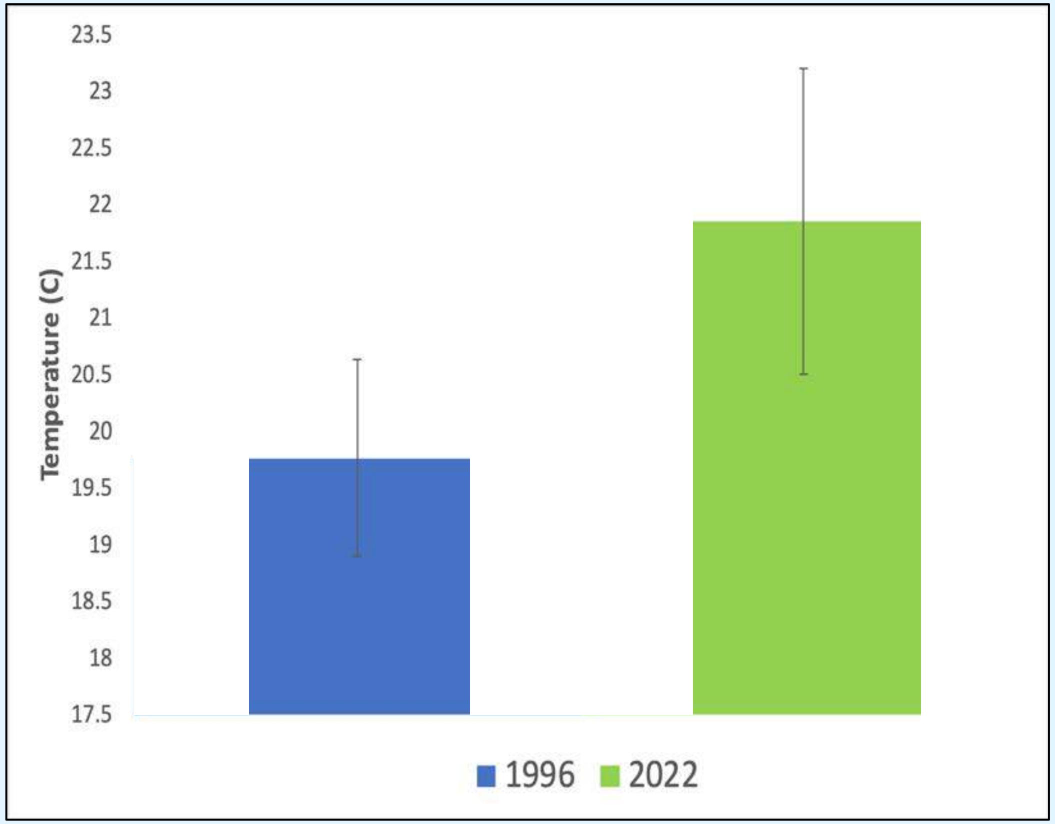


19 lakes pass critical pH of 5.5 for lake charr reproduction!

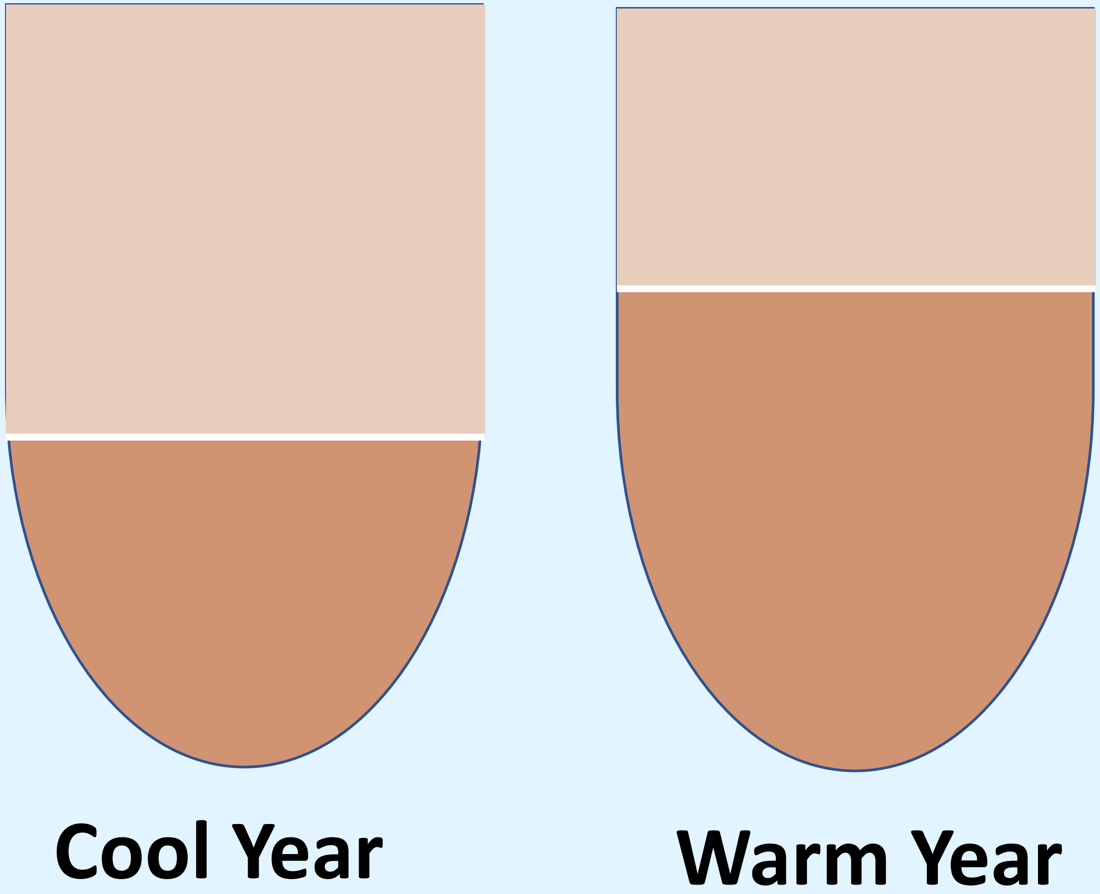
Lakes are getting “healthy colour” back



Surface temperatures are getting warmer (2°C)



DOC >2mg/L expands and protects the hypolimnion



Snucins and Gunn 2000

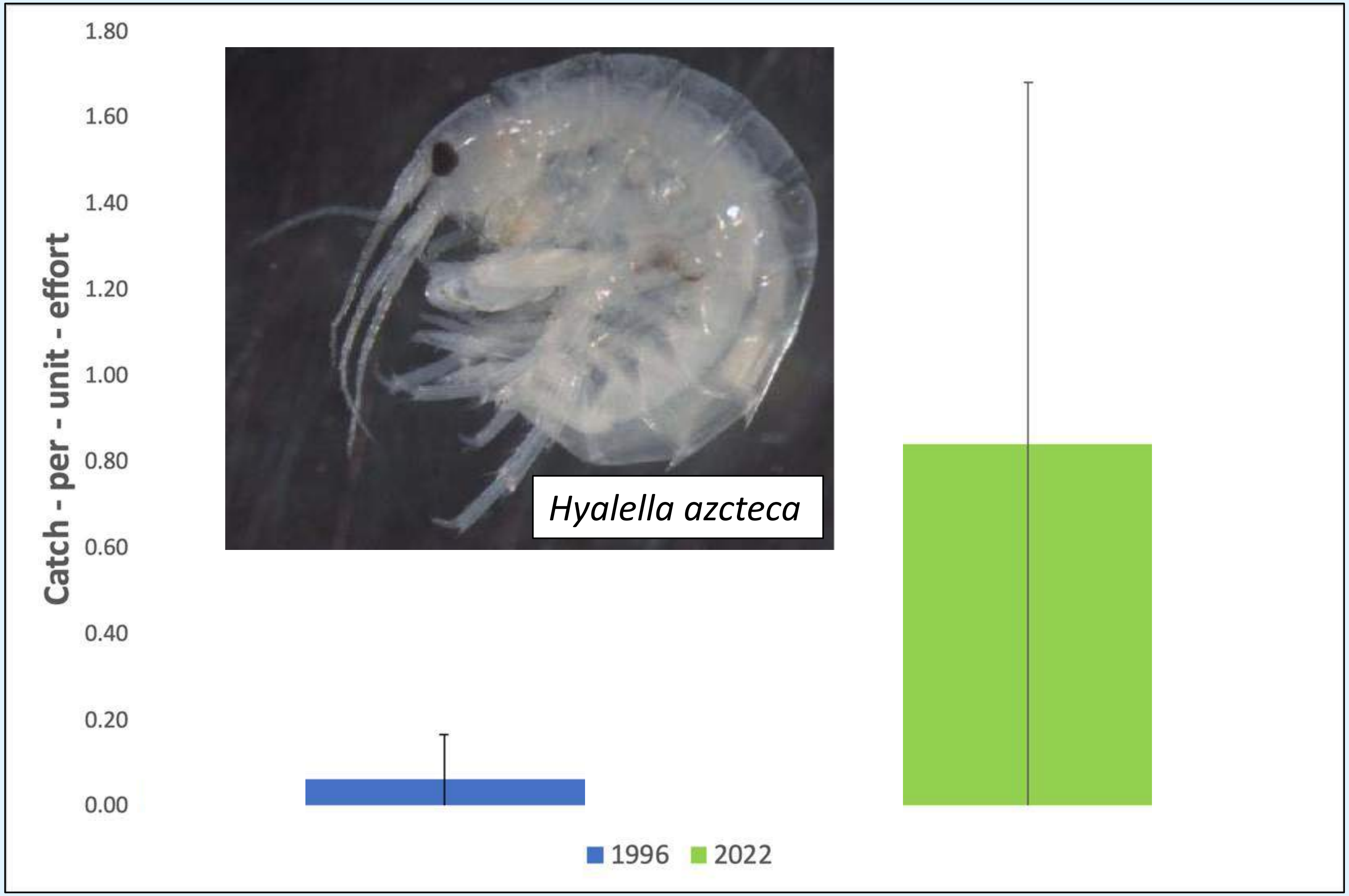
Invertebrate Survey of Potential Food Source for Early Life Stages of Lake Charr

Amphipod

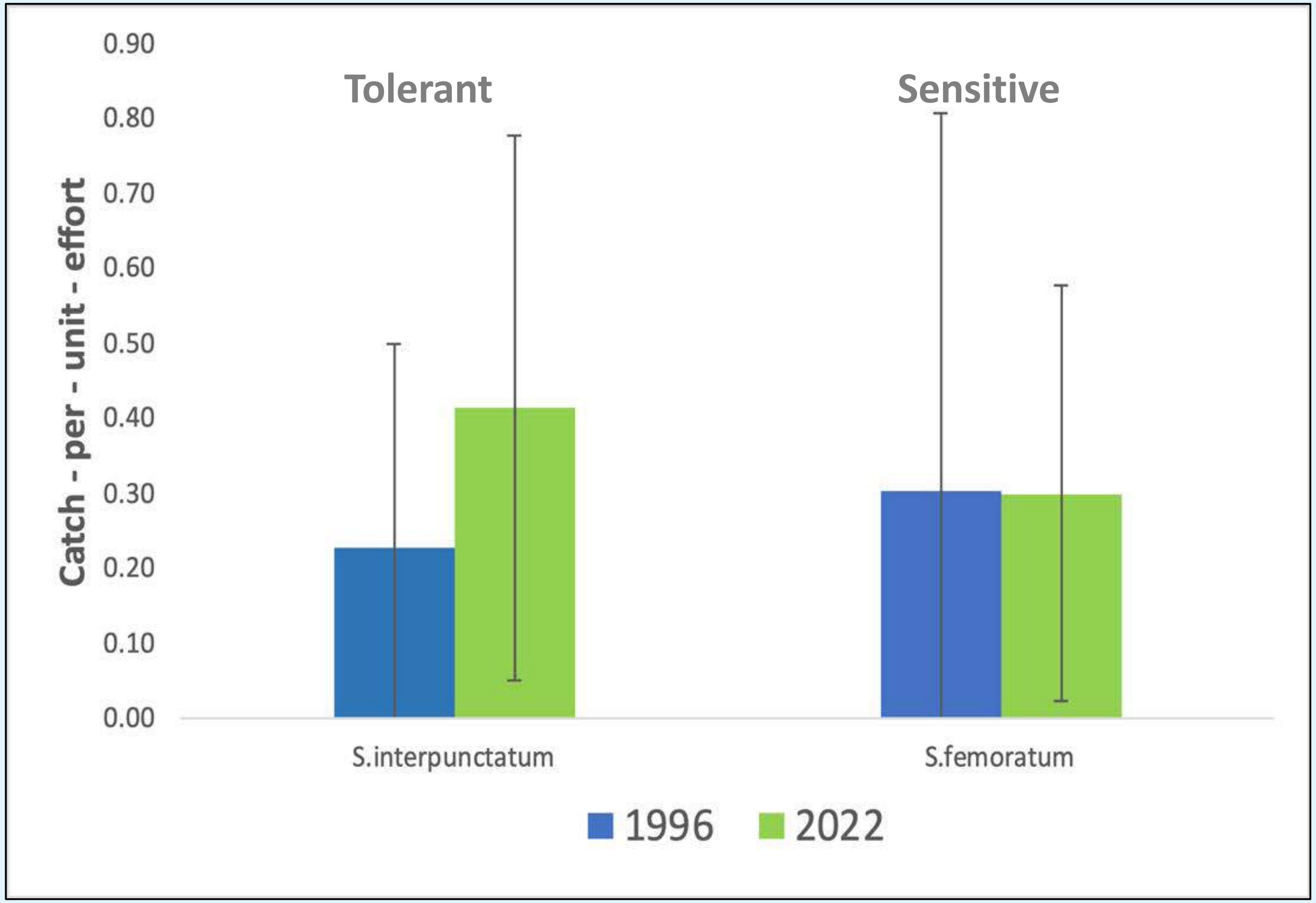
Mayfly

Chaoborus

Increase in Sensitive Amphipods



Acid-tolerant Mayflies increase in abundance
No change in sensitive species



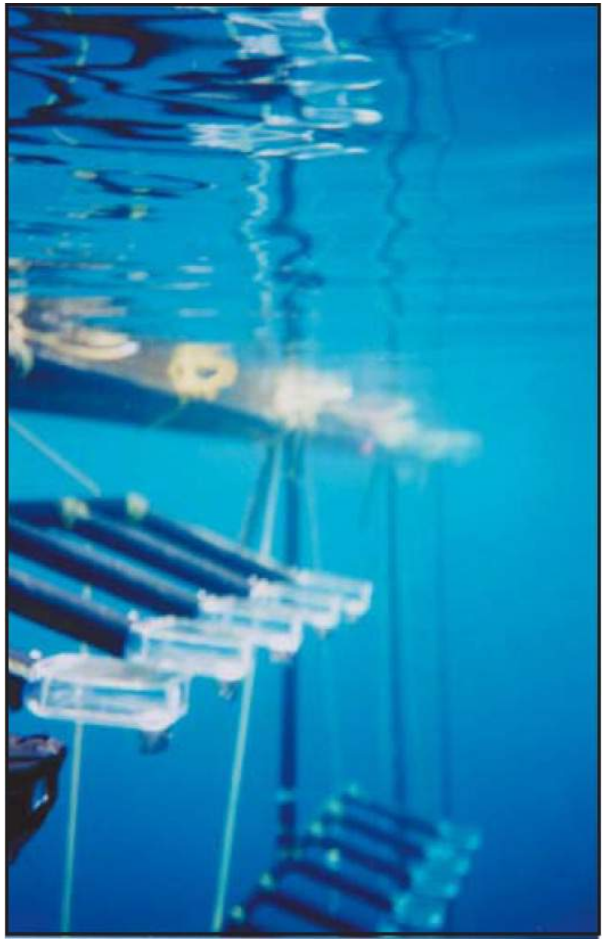
Zooplankton Responses: 2022 Preliminary Findings

Haley Moskal

Dr. Brie Edwards

- Large bodied Cladocera slow to recover
- Rapid increase of Chaoborus in the water column
- No recent info on littoral zone plankton since Walseng 2003

Experiments in ultra-oligotrophic Ruth Roy Lake (Surface Area: 54ha, Max depth: 18m) with deadly levels of UVR for Chaoborus



Persaud and Yan 2003

Historic Conditions (Paleo inferred) Simmantris et al. 2023 (CJFAS)

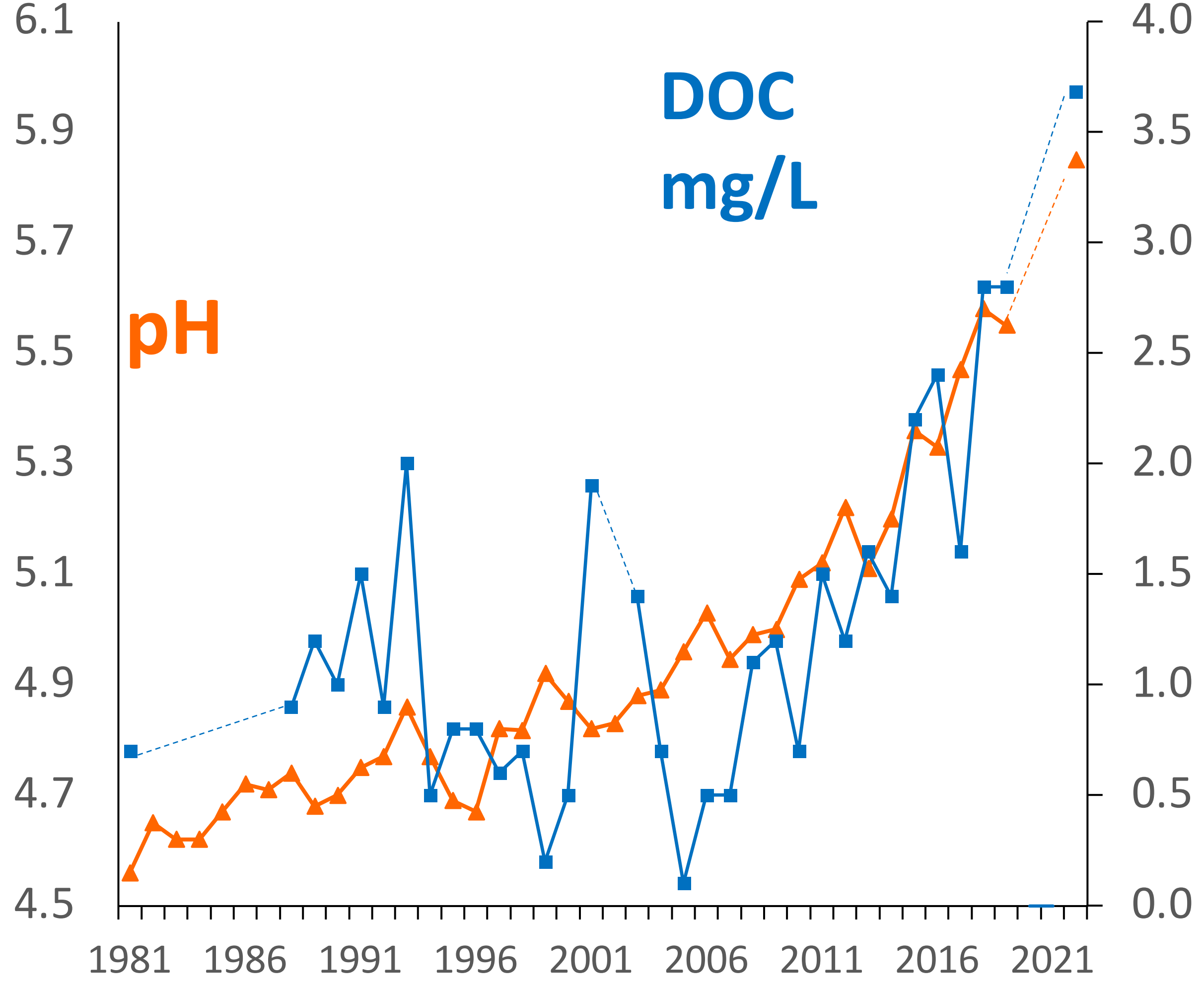
Pre-industrial pH: 4.8

Atmospheric Acidification period (to pH 4.6): 1925-42

1995 Limnological Survey Snucins and Gunn 1998

pH	4.9
Ca	1.2 mg/L
DOC	0.2 mg/L
Total P	<4 µg/L
Isothermal (bottom temp)	17.0°C

Recent changes in DOC and pH in Ruth Roy Lake



OMECP Monitoring Data

Novel Reintroduction Technique:
Stocking of Hatchery Reared Lake Charr (*Salvelinus namaycush*) Embryos

Matching introduced fish size to size of available food source

25 Years Later

Chaoborus abundant in diet, dramatic Lake charr growth

March 2021

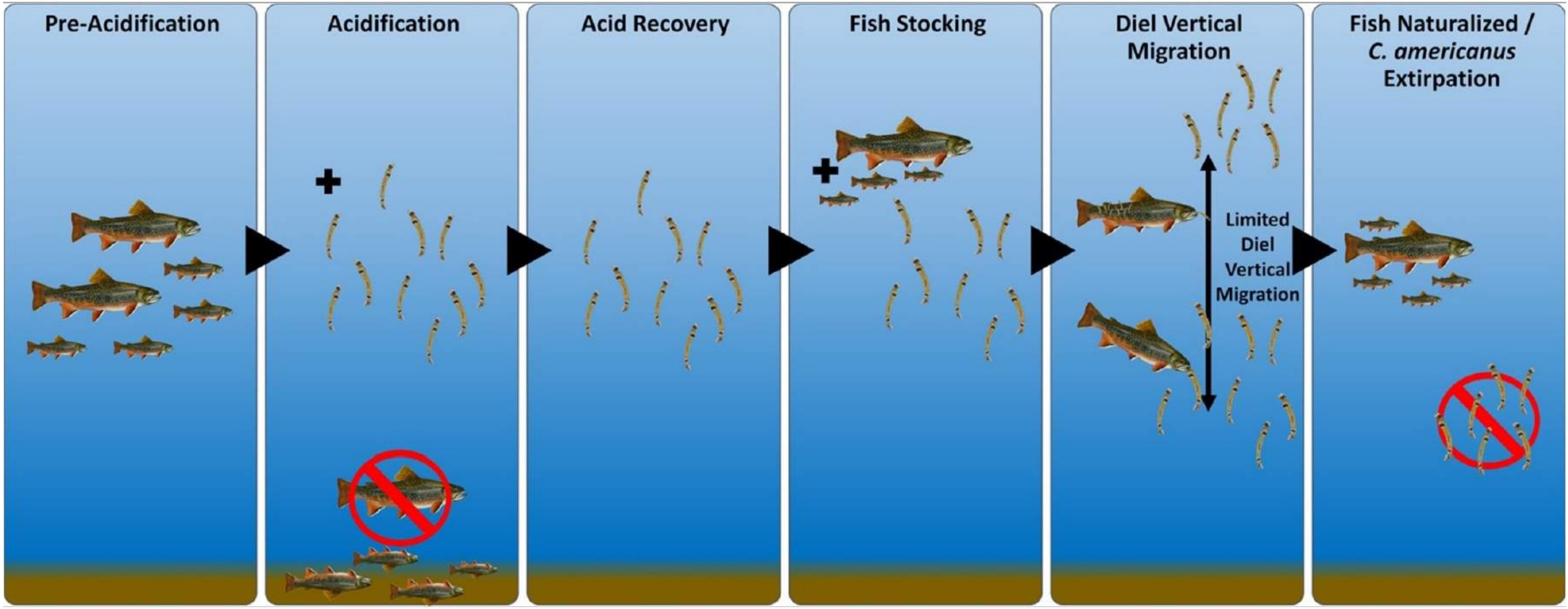
September 2022

Stomach contents

Can growth be sustained without repatriation of prey fish species?

Expectations for typical low pH (~5.0) low DOC (0.7-2.0mg/L) lake

Brooktrout Lake, Adirondack Mountains (USA)



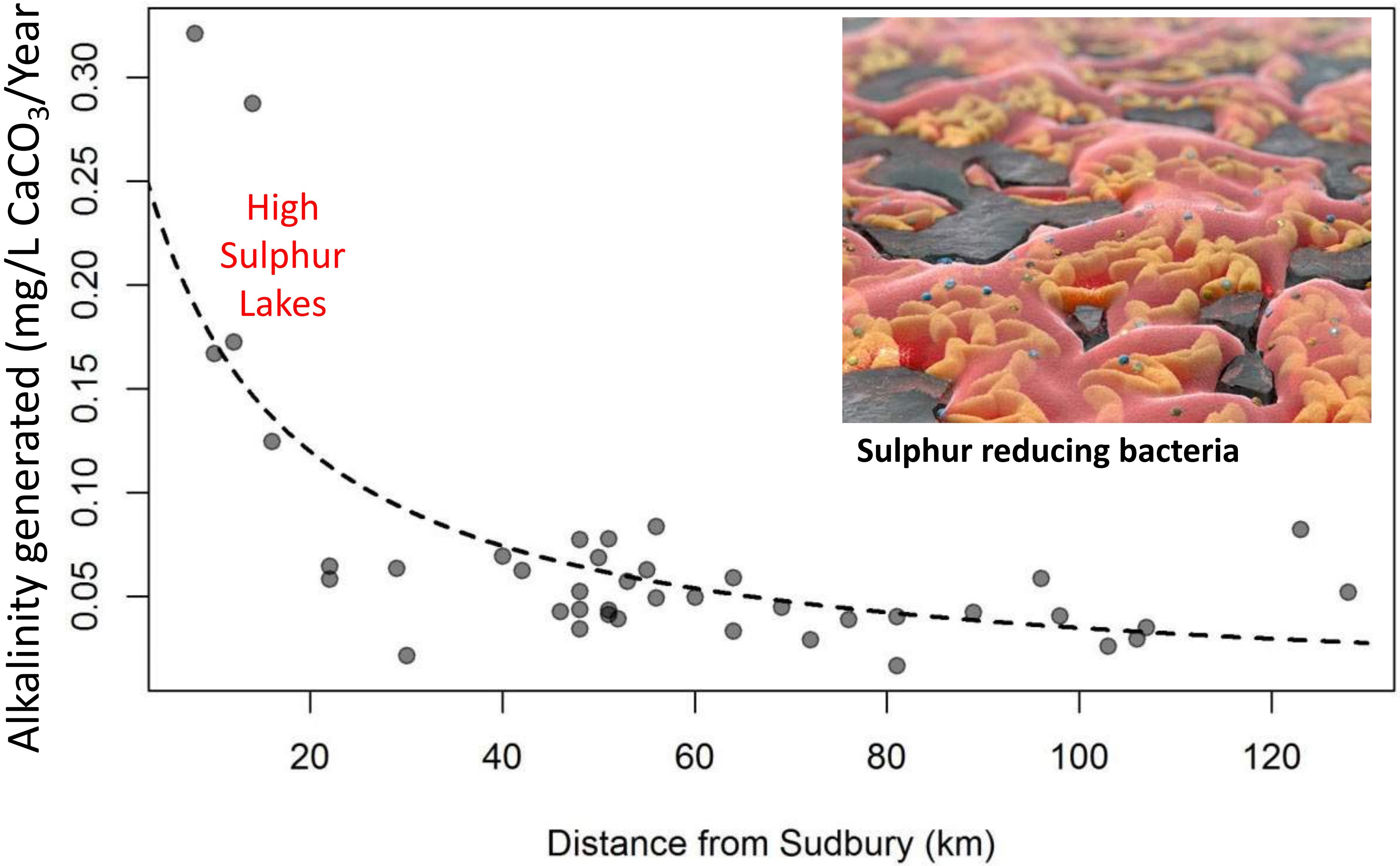
Sutherland et al. 2015 ES&T
Farrell et al., 2017 Limnologica

DOC Ultra Clear Lake Summary

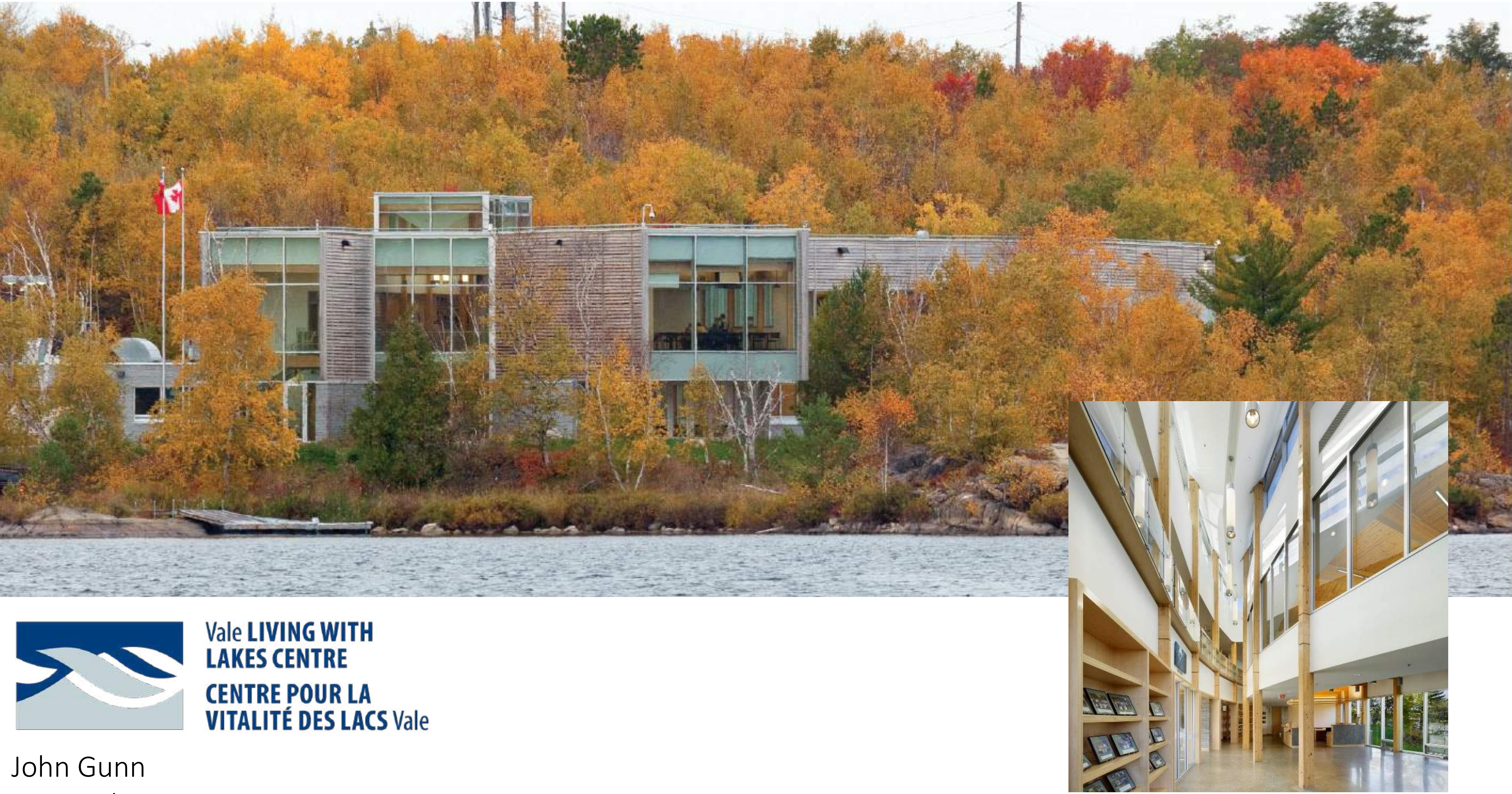
- rising to pre-industrial levels
- serving as a nutrient
- protecting thermal structure
- providing sunblock for sensitive species

Is DOC and residual atmospheric sulphur (through sulphate reduction) the fuel for recovery in low nutrient acid-damaged lakes?

Lakes most contaminated with sulphur recovered the fastest



Sulphur reducing bacteria



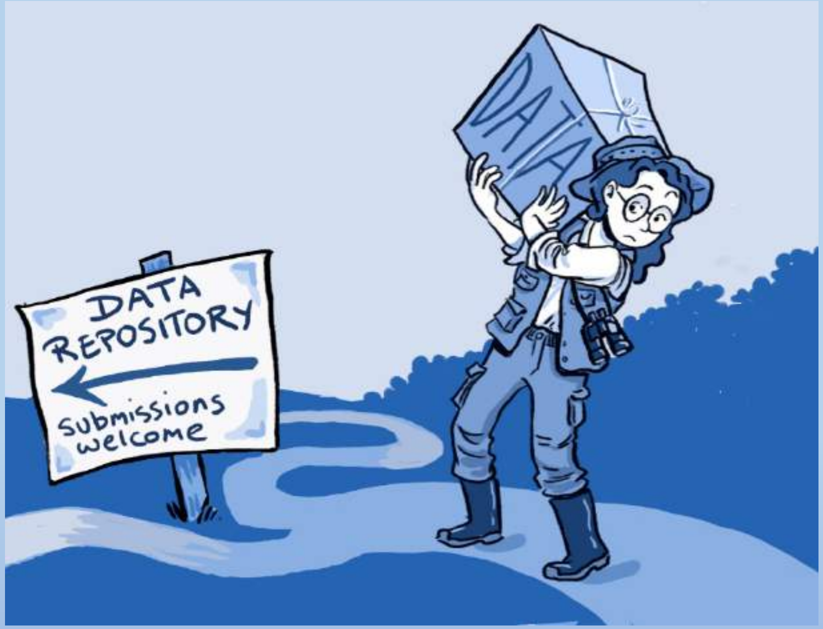
Vale LIVING WITH LAKES CENTRE
CENTRE POUR LA VITALITÉ DES LACS Vale

John Gunn
jgunn@laurentian.ca

Data and R tool sharing for the calculation of acidification indices for macroinvertebrates: a step forward on the ICP waters Italian contribution

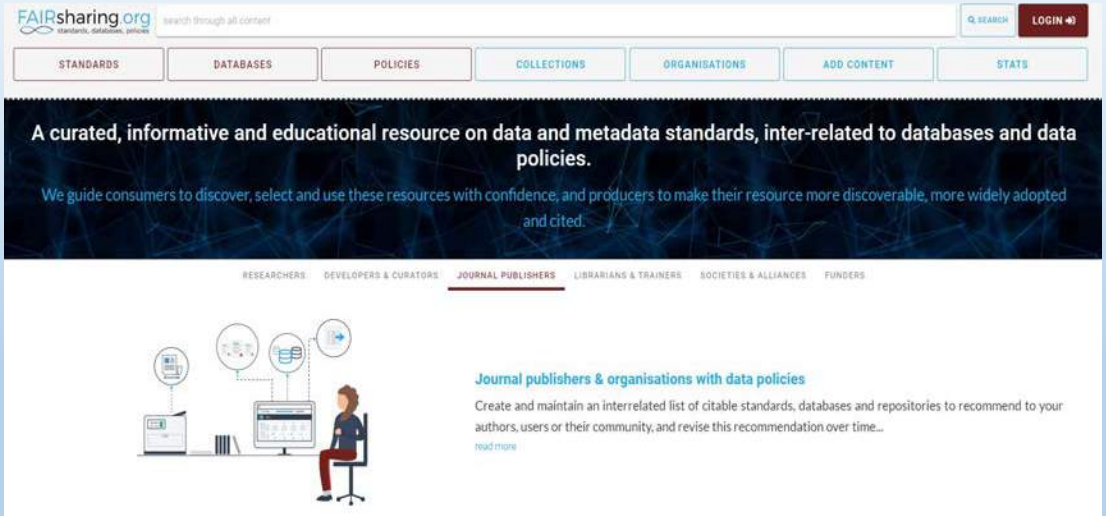
Boggero A., Dumnicka E., Rogora M., Zaupa S., Fornaroli R.

Data sharing is the practice of making data ((raw data, statistical methods or source code), collected or developed within the framework of several European and national projects, useful for scholarly publication available to other researchers



To encourage data sharing and prevent the loss of data, a number of journals or Institutions established policies on data archiving.
Access to publicly archived data is a recent development in the history of science.

FAIR - Findability, Accessibility, Interoperability, and Reusability



4 main steps

1. identify data sources and participants
2. develop the infrastructure for data interoperability and collaboration
3. build trust across the spectrum of data sharing practices and governance
4. develop skills and capabilities for a data-driven culture

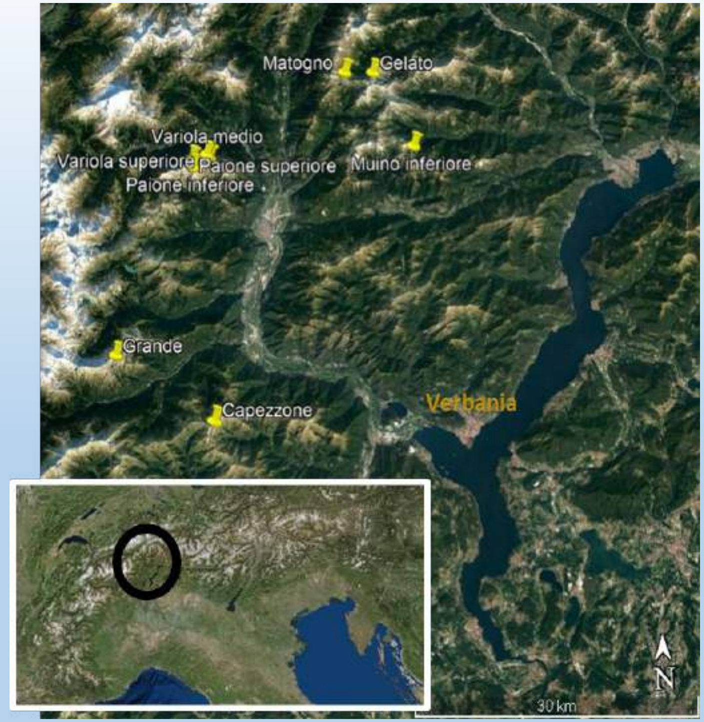
bedrock elements

2 main issues

1. the hesitation of researchers or Institutions to share information
2. concerns about data quality

The ICPwaters Italian contribution (1)

Valley	Lake name	Altitude	Latitude N	Longitude E	inlet	outlet
		m a.s.l.	WGS 84 decimal degrees			
Agarina	Gelato	2418	46.24843	8.44028	no	no
Agarina	Matogno	2087	46.24947	8.40237	x	x
Anzasca	Grande	2214	46.00184	8.07801	no	x
Bognanco	Paione inferiore	2006	46.16924	8.19024	x	x
Bognanco	Paione di mezzo	2145	46.17252	8.19076	x	x
Bognanco	Paione superiore	2251	46.17591	8.18991	no	x
Bognanco	Variola medio	2137	46.17707	8.21402	x	x
Bognanco	Variola superiore	2198	46.17980	8.21010	no	x
Strona	Capezzone	2100	45.93810	8.20895	no	x
Vigezzo	Muino inferiore	1886	46.18085	8.49251	no	x



Chemical data of lakes Paione (LTER sites)

DOI 10.5281/zenodo.7642703   DOI 10.5281/zenodo.7642499

LTER Italia

Study area included within the Lake Maggiore watershed (NW Italy, Piedmont, Central Alps)

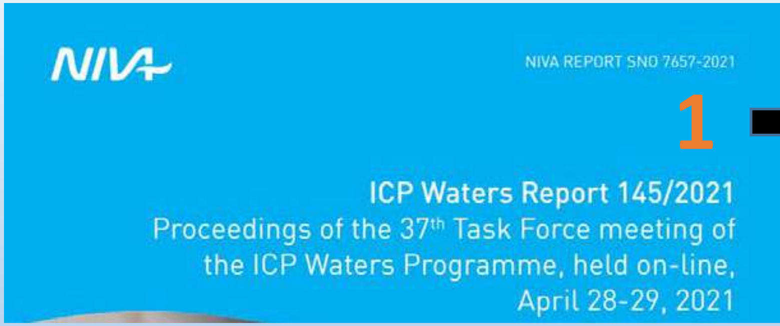
The biological data set includes:

- 2111 records on **temporal** fragmentary **data** from lakes Paione (upper, middle, and lower lakes Paione) spanning over the period 1989-2020
- 530 records on **spatial data** relative to eight other high-altitude lakes from the Ossola Valley referring to the 2019-2020 sampling activity
- All records are **georeferenced** because of sampling in the same sites over years

LIFE MODERN NEC

LIFE20 GIE/IT/000091

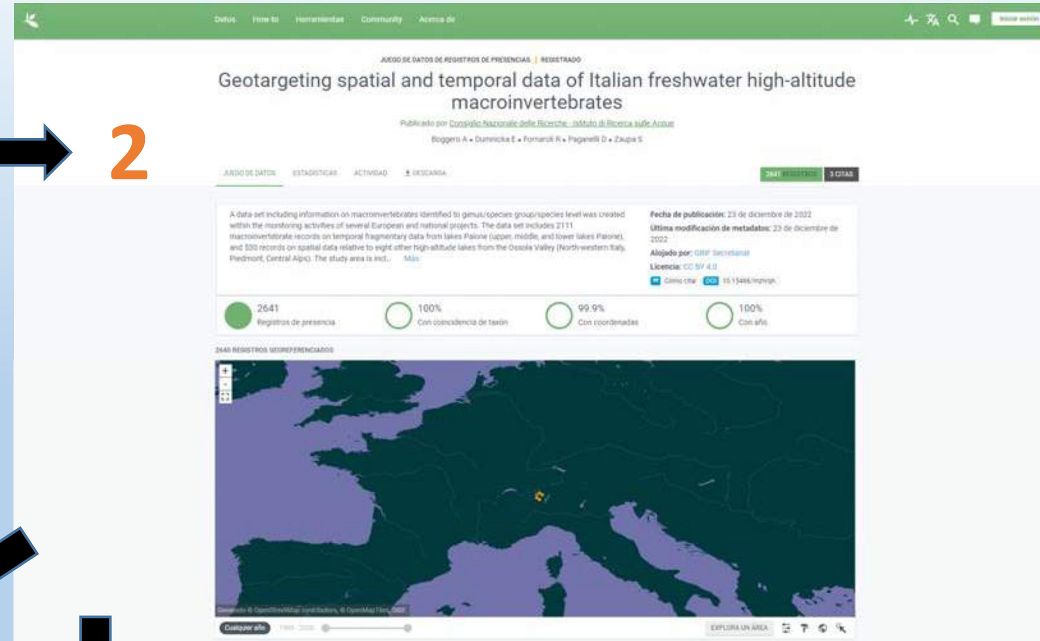
https://www.icp-waters.no/2021/



1

https://GBIF.org - https://doi.org/10.15468/mzhrqh via

2



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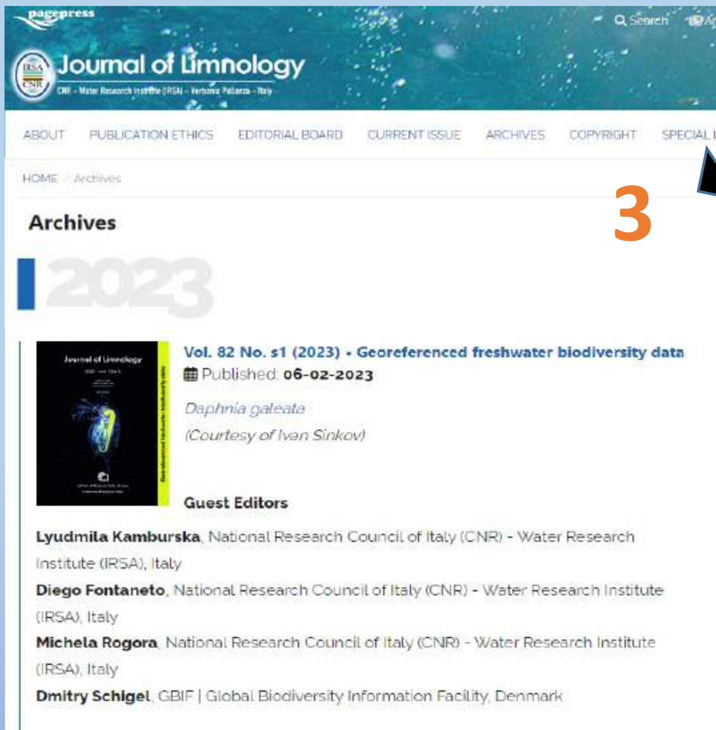

https://doi.org/10.4081/jlimnol.2023.2104

4


GEOREFERENCED FRESHWATER BIODIVERSITY DATA

Geotargeting spatial and temporal data of Italian freshwater high-altitude macroinvertebrates

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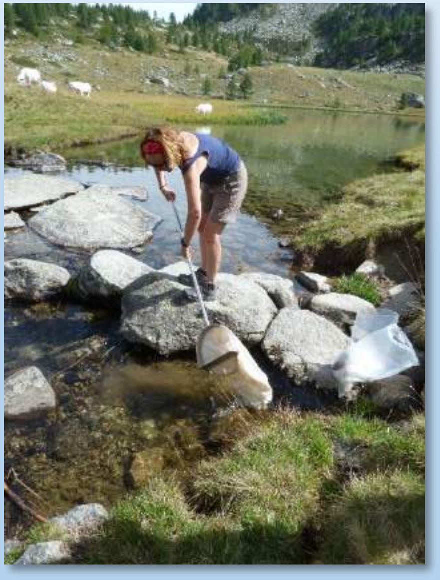
https://www.jlimnol.it/index.php/jlimnol/issue/view/81

The ICPwaters Italian contribution (2)

an **R tool** for the consistent use of:

- already available **acidification indices**
- to provide the basis for the development of new ones
- to calculate **generic metrics** of diversity, richness and functional aspects



The indices for which the calculation is already implemented are reported below:

1. Raddum 1988 index (Raddum et al., 1988), rivers and lakes - Norway
2. Raddum 1990 index (Fjellheim & Raddum, 1990), rivers and lakes - Norway
3. NIVA index (Bækken & Kjellberg, 2004), humus-rich streams - eastern Norway
4. $AWIC_{fam}$ index (Davy-Bowker et al., 2003, 2005), streams/rivers - England/Wales
5. $AWIC_{sp}$ index (Davy-Bowker et al., 2003), streams/rivers - England/Wales
6. Braukmann index (Braukmann & Biss, 2004), streams/rivers - Germany
7. LAMM index (McFarland et al., 2010), clear/humic lakes - UK
8. TL index (Hämäläinen & Huttunen, 1990), streams/rivers - Finland

1) total N. taxa (Ofenböck et al., 2004)
2) N. taxa, families and % EPT single families, and whole EPT (Böhmer et al., 2004; Ofenböck et al., 2004)
3) N. taxa and % chironomids/oligochaetes (Wiederholm, 1980)
4) Shannon diversity index (Shannon & Weaver, 1948)

https://github.com/RiccardoFornaroli/AcificationIndexes/

For those asking the link to cooperate

Next steps

- To validate the R tool using other biological data already available

(**ICP water contribution appreciated**)

- To include the R toll in an already existing R packages such as **biomonitoR** https://github.com/alexology/biomonitoR

a package for managing taxonomic and functional information and for calculating indices for biomonitoring of running waters with a focus on macroinvertebrates

PeerJ

biomonitoR: an R package for managing ecological data and calculating biomonitoring indices

Alex Laini[1,2], Simone Guareschi[3,4], Rossano Bolpagni[1], Gemma Burgazzi[5], Daniel Bruno[6], Cayetano Gutiérrez-Cánovas[3], Rafael Miranda[7], Cédric Mondy[8], Gábor Várbíró[9] and Tommaso Cancellario[7,10]

https://peerj.com/articles/14183/


Thank you for listening!!